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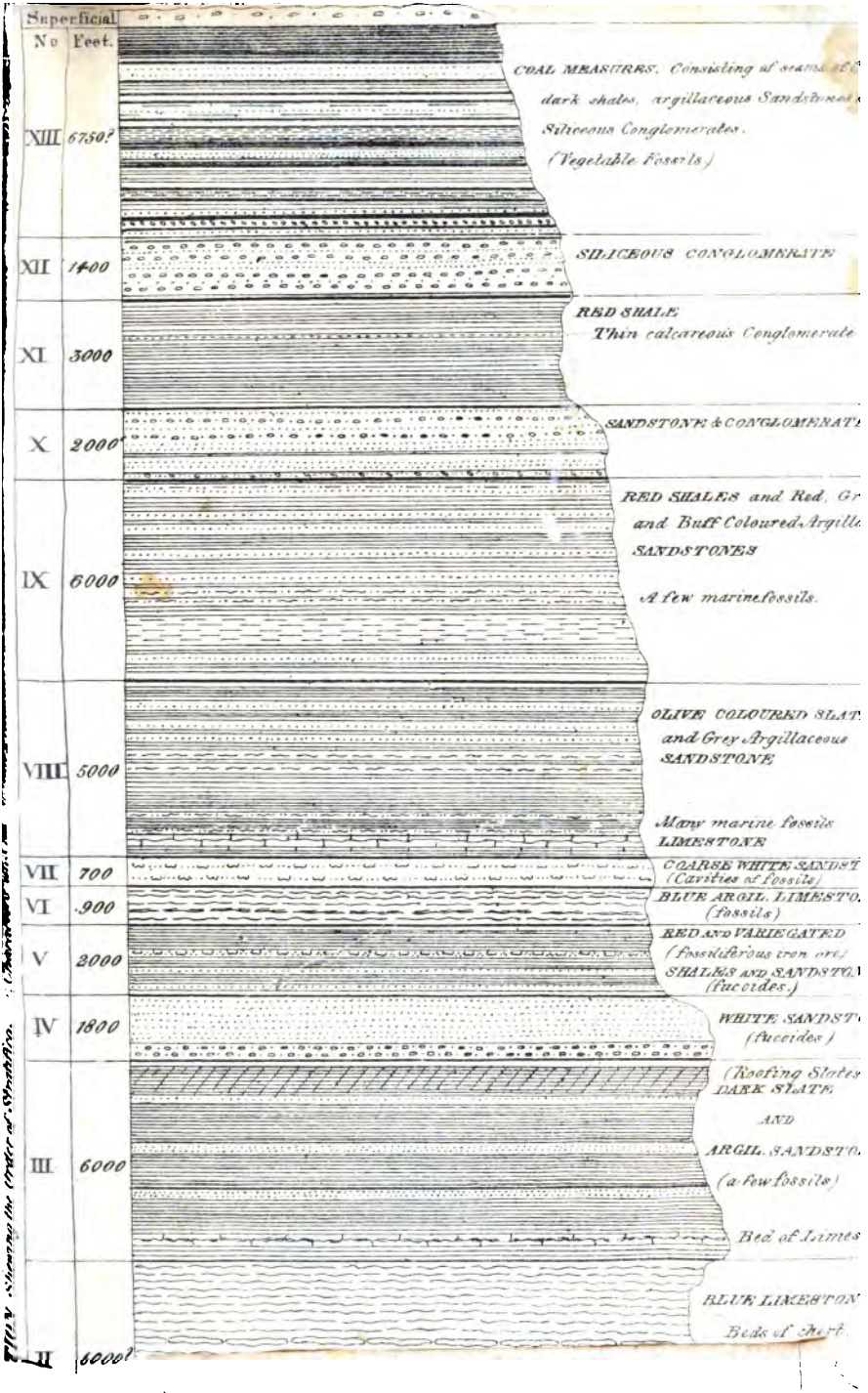
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(Vegetable Fossils)
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XI
3000
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X
2000?
SANDSTONE & CONGLOMERATE
IX
6000
RED SHALES and Red, Gr
and Buff Coloured Argilla
SANDSTONES
A few marine fossils.
VIII
5000
OLIVE COLOURED SLAT
and Grey Argillaceous
SANDSTONE
Many marine fossils
LIMESTONE
VII
700
COARSE WHITE SANDST
(Cavities of fossils)
VI
900
BLUE ARGIL. LIMESTO
(fossils)
V
2000
RED AND VARIEGATED
(fossiliferous iron ore)
SHALES AND SANDSTO
(fucoides.)
IV
1800
WHITE SANDST
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III
6000
(Roofing Slates
DARK SLATE
AND
ARGIL. SANDSTO
(a few fossils)
Bed of Limes
II
6000?
BLUE LIMESTON
Beds of chert

John C. Brannen
From Noble Heart.
July 85

SECOND ANNUAL REPORT

ON THE

GEOLOGICAL EXPLORATION

OF THE

STATE OF PENNSYLVANIA.

BY HENRY D. ROGERS,

PROFESSOR OF GEOLOGY AND MINERALOGY OF THE UNIVERSITY OF PENNSYLVANIA.

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READ IN HOUSE OF REPRESENTATIVES, FEBRUARY 1, 1838.

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SECRETARY'S OFFICE,
Harrisburg, Feb. 1, 1838.

To the Speaker of the House of Representatives:

SIR—In accordance with the acts of Assembly on the subject of a Geological Survey of the State, I herewith transmit the annual report of the State Geologist.

I am, Sir,
Very respectfully,
Your ob't serv't,
THO. H. BURROWES,
Secretary of the Commonwealth.

REPORT

OF THE

STATE GEOLOGIST.

To the Secretary of the Commonwealth of Pennsylvania:

Sir—In compliance with my duty as State Geologist, I respectfully present to the Legislature, the following report of the progress which has been made in the Geological Survey of the State, during the past year.

In my former report, reasons were submitted somewhat at length, for excluding from my annual narrative of the operations of the survey, any detailed account of the facts ascertained during each season, and for presenting the whole of the results in one mass at the close of the survey, in the form of a comprehensive and properly matured description of the mineral resources of the State.

Another year's experience in conducting the work, with increased opportunities of intercourse with the people of the Commonwealth, have fully assured me, not only of the discreetness of the course adopted, but of its having met with the cordial acquiescence of our citizens.

I shall, therefore, in the present communication, after mentioning the districts of the State into which the survey has been carried during the past year, give a brief account of the mode of conducting the Geological examinations, and afterwards offer a short sketch of some of the general results obtained; abstaining as far as practicable from introducing, for reasons already before the public, the minute and local descriptions more appropriate to an advanced stage of the survey.

CHAPTER I.

OF THE SEAT OF THE OPERATIONS OF THE SURVEY.

The last Legislature having amended the act providing for the Geological Survey of the State by increasing the appropriation, with the view of adding two assistants, and of augmenting the fund set apart for the incidental expenses of the survey, it became my duty to make a new organization of the Geological corps upon the enlarged scale contemplated. Though solicitous to commence the active operations of the season with the full complement of assistants authorized by the act, it was found impracticable to embark with any increase of force beyond that of the former year; nor was it until the month of July, that after very diligent inquiry, I succeeded in supplying the survey with assistants of competent talents. The difficulty was in part occasioned by some unforeseen resignations, but more particularly, by the extreme scarcity at present felt every where throughout our country, of scientific persons of accurate knowledge and practical skill in the Geological profession.

I am happy to have it in my power to state that the survey is now supplied with the whole number of assistants authorized, namely, five; four of whom are aiding me in the Geological duties, and one in the Chemical analysis. Out of the fund designed for the incidental expenses of the survey, I was enabled during the latter half of the season, to secure the services of four additional aids, who acted in the capacity of sub-assistants; and who, by taking an active part in the collection of specimens, and in the numerous minute measurements required, have promoted very essentially the progress of the work.

The four Geological assistants are Messrs. SAMUEL S. HALDEMAN, ALEXANDER M'KINLEY, CHARLES B. TREGO and JAMES D. WHELPLEY, and the Chemical assistant is my brother, Dr. ROBERT E. ROGERS; all of whom merit a high encomium for the zeal and ability with which they have executed the often arduous duties which I have assigned to them.

The sub-assistants were Messrs. ALFRED F. DARLEY, EDWIN HALDEMAN, HORACE MOSES and PETER W. SHAEFFER; who likewise discharged their duty with much diligence, and a praiseworthy fidelity to the interests of the survey.

Notwithstanding the delay in getting the corps fully organized, it is believed a large amount of systematic and minute Geological research has been accomplished; for in consequence of the favorable character

of the weather during the past autumn, operations in the field were actively prosecuted until the middle of November—a period later by several weeks than that which may occasionally terminate the season.

Through the zealous aid which I have received from the assistants and sub-assistants engaged in the survey, the observations made during this year, will be ultimately elucidated by a large and carefully selected series of characteristic specimens of our rocks, coals, ores and other minerals, exceeding probably Two Thousand pieces in number. These are now undergoing a minute examination, and receiving a temporary classification; such of them as require it, being set apart to be chemically analyzed or tested, preparatory to placing the whole collection, when the survey shall be sufficiently advanced, in the State Geological Cabinet.

It was contemplated in the early part of the season, to explore in more or less detail, all that portion of Pennsylvania included between the Delaware river from Easton to the New York line, on one side, and the Susquehanna from Middletown to Tioga Point, on the other, extending from the South Mountain to that part of the northern boundary of the State embraced between these two rivers. All the Anthracite coal regions and a wide circumjacent country would have been thus examined. Partly from the difficulty already referred to, of procuring adequate assistance at a sufficiently early period of the season, but more especially from the magnitude of the task itself, it soon became apparent that a portion only of this large territory could be minutely traversed; and this portion was further circumscribed by the time consumed in the detailed measurements which it became necessary to institute in exploring the several coal fields.

The investigations of the survey have been, during the past season, directed more particularly to the minute features of the several anthracite coal regions included within the general district allotted for examination. The great southern basin, lying chiefly within Schuylkill county, has received the most minute inspection; several portions of it having undergone as thorough an examination as the data supplied by the existing mines rendered practicable at the present time, though much remains yet to be seen before I can draw up a complete account of its resources, and explain the intricate features which these often present.

The most northern anthracite regions, those of the Wyoming and Lackawanna valleys, have in like manner undergone an extensive series of minute measurements, and have been explored somewhat in detail.

A less minute, though a still considerable degree of attention has been given to that part of the great middle coal region which lies between the head waters of the Little Schuylkill and the Lehigh rivers, including the Beaver Meadow, the Hazleton, and the several neighboring coal fields.

I am gratified to be able to state that though these researches in the several anthracite districts are, in consequence of the vast multiplicity of the points that needed examination, far from being terminated, they have already resulted in the development of facts of very high practical interest, calculated to lend greater certainty and expedition, in the discovery of coal in numerous new places, and to assist materially, it is hoped, by the sounder views which they may hereafter introduce concerning the structure of these basins, to the recovery of some of the coal seams, which from the nature of their dislocations, are daily deceiving the anticipations of the miner.

Much active capital is annually thrown away in our several coal regions, from a want of knowledge on the part of those interested, regarding certain features in the structure of particular parts of these basins, which cause many tracts that are externally promising, to be almost wholly unproductive. The survey, by making the true structure of these districts better known, has already done something, and will hereafter, it is believed, when the facts are ready to be published, effect much more, to check this waste of capital, and give it a more useful direction.

Some valuable and extensive deposits of iron ore, have been explored in the formations external to the coal regions, and such data collected concerning them, as must tend greatly to facilitate the development of the same ores in the corresponding formations in other districts of the State.

Besides the researches undertaken in the various Anthracite coal basins, a large extent of country, embracing the several formations below the coal, has been traversed, and in certain tracts minutely explored, where the nature and quantity of particular mineral deposits rendered such close attention necessary.

As many extensive districts, amounting in some counties to nearly their entire surface, possess a very simple, monotonous Geology, comprising only one or two well known formations, which were early ascertained to include but few valuable mineral substances, and those in very insignificant quantity, I have deemed it essential to the frugal use of the funds and time of the survey, to exercise a discretion as to

the degree of minuteness of the exploration proper to each neighborhood. It is obvious that some quarters of the State, owing to the amount of their mineral productions, and to the intricate manner in which they are distributed, must require a far larger share of close and detailed investigation than other regions relatively barren in these resources; at the same time I would remark, that every section of the State will be examined with that degree of scrutiny necessary to determine the absence or existence, and the relative scarcity or abundance of those mineral deposits which possess a value from their useful applications. I mention this, because disappointment may otherwise be felt at no explorations having yet been made of particular places, containing, or supposed to contain, materials of practical importance. Many such places within the counties where the survey has been in progress, have not yet been explored; some from a conviction based on a previous familiarity with the formation, that they do not deserve the time it would require, and some in consequence of the investigations in the particular districts not having yet been terminated. I deem it necessary in Geological researches generally, for the sake of insuring accuracy, and for the avoidance of errors and omissions, that the explorer should revise many portions of his work, and make use of the fresh accessions of more and more exact knowledge which he is daily acquiring. Upon this principle, numerous districts, which some who are not familiar with the nature of Geological research, may fancy to have been superficially traversed, are designed to be again examined in certain portions, and under far more favorable circumstances for exactness in the results than could exist at first, when the materials appropriate to each formation had not as yet been ascertained.

The following sections of this report, describing the nature of some of the more refined operations of the survey, and a portion of the general results arrived at in the prosecution of the work, will convey a more just idea of the amount of investigation performed, and the degree of detail introduced into it, than could possibly be made known through a mere enumeration of the districts visited and explored.

CHAPTER II.

MODE OF CONDUCTING THE GEOLOGICAL INVESTIGATIONS.

I now proceed to describe concisely the manner in which the field operations of the Geological Survey have been conducted. Some brief statements on this subject may operate to dispel certain erroneous notions, which many entertain throughout the State, in regard to what is really within the reach of Geological research, and at the same time, inspire a deserved confidence in the precision, the variety and practical value of those results which are attainable.

The legitimate objects of a Geological Survey, the intention of which is general, and public utility, should consist, I conceive, in determining :—

First. The nature of the various rocks comprised in the region explored, and the mineral substances which they enclose.

Secondly. The extent of country which each species of rock and its associated minerals (or in technical language, each *formation*) occupies, delineating the limits of every such mineral area on some map of adequate size and accuracy.

Thirdly. In establishing the order of *superposition*, not only of all the several formations, considering each as a group comprising numerous strata, but also, of the multifarious sub-divisions, or beds, composing the respective formations; ascertaining, at the same time, the *thicknesses*, severally of each individual stratum and group of strata, more especially where there are materials of direct value, such as, coal, iron ores, or useful rocks, forming a part of the series.

Fourthly. In determining, for as great a multitude of places as possible, the angle and direction of the dip, (or slope) of the strata, in order to compute to what depth any known bed or layer descends below the surface in any particular neighborhood.

Fifthly. In ascertaining as nearly as possible, the *configuration of the surface*, so as to be able from observations made on the range, the thickness and the dip of the strata, to calculate, among other results, at what places on the surface, any regular mineral deposits that we may be tracing, will shew themselves.

Sixthly. In detecting and tracing those contortions, and those abrupt *dislocations* of the strata, which in so many rich mineral districts occur to frustrate the hopes, and to baffle the skill of the industrious miner.

An accurate knowledge of these irregularities in the Geological structure of a region, is only to be gathered from an inspection, both extensive and critical, of its mines, and from the features sometimes seen in the exposed portions of its surface. Every person, at all familiar with mining regions, will perceive the incalculable advantage to any disturbed mineral district, of this kind of knowledge regarding it.

SEVENTHLY. A judiciously conducted survey must of course include an examination of all those mineral substances, not regularly disposed in strata, but dispersed with less method either in the soil or the solid rocks, which from their properties and their quantity promise to be useful to society. The mode of tracing these materials is more desultory than that where the deposits are regularly stratified, and in the following account of the methods of examination adopted, little will be said regarding this branch of Geological research, as few rules can be laid down to assist investigation, where success depends chiefly on experience, guided by a knowledge of the principles of the science and of the Geology of the particular country to be explored.

In entering upon the detailed investigation of the country included between the Susquehanna and Delaware rivers, which was the principal theatre of the operations of the survey during the past year, a sufficiently correct, general knowledge of the formations of this part of the State had been previously acquired, to render it wholly unnecessary to make, (as was done in the previous season,) any reconnoisance of the region by crossing the country transversely to the range of the strata, a preliminary step of the greatest consequence when the general structure of a district is not already definitely known. A more minute species of exploration was therefore commenced early in the season. A triple sub-division of the whole region being made, the central portion, including all the Anthracite tracts of the State, was confided to two of the Geological assistants, but owing to the highly responsible nature of the researches, I devoted by far the largest share of my own personal labors and superintendence to this quarter. To another assistant was allotted the country laying north east, and north of the several Anthracite coal regions; while the fourth assistant, was charged with the examination of the section included between the south mountain and the blue mountain. From the comparative intricacy of the Geology of this last division, and from its abundant mineral resources in the shape of iron ores, roofing slates, limestone and other materials, I bestowed on it, next to the southern Anthracite region, the largest proportion of my time and personal study.

The north-eastern and northern counties of the quarter of the State under investigation, being marked by great uniformity and simplicity of structure, and containing formations relatively less abundantly supplied with useful mineral substances, this division was conceived to claim for the present, a smaller share of my individual attention.

Throughout these several sub-divisions of the State, a very considerable progress has been made, in tracing the boundaries of each of the formations and in delineating them upon the map.

An ample collection of specimens, illustrating both the more immediately useful, and the scientifically interesting facts in the Geology of the region, was at the same time gathered. Mines, excavations of all kinds, and the natural exposures of the rocks and minerals were visited and explored, wherever any hope was entertained of their affording an insight into the resources and structure of the country in their neighborhood in regard to points not previously established.

The various investigations already alluded to as constituting the inquiries essential to a properly conducted Geological Survey, having been pursued with as much minuteness and method as was practicable amid the impediments arising from the gross defectiveness of the State map, from the wilderness condition of many parts of the regions explored, and the natural intricacy in the Geology of other portions of the country, it is unnecessary to dwell in detail, on all the methods resorted to for collecting the imformation sought. I deem it quite proper however, to call attention to the use made, in the operations of this year, of various kinds of surveying instruments, introduced for the purpose of imparting increased accuracy to many of the investigations.

To procure a correct knowledge of the actual position, and the true magnitude of the mineral deposits, as coal, certain kinds of iron ore, and other valuable beds composing part of the strata of any region, it is indispensible that numerous measurements be performed with the compass, or what is better, with the theodolite, the chain, the level, and the barometer, to astertain the thickness of each formation, and in some cases of each separate stratum.

In performing these measurements, the method is to select some spot, the neighborhood most usually of a stream, where the rocks are sufficiently exposed to display their numerous beds, with their dip or inclination to the horizon, and whatever other important features of stratification they may possess. The more nearly perpendicular to the course of the strata, the general direction is of such natural sec-

tions of the rocks, the less is the intricacy of the measurements, and the simpler are the calculations necessary to show the true place and thickness of each bed and formation in the series. It so results from the peculiar nature of the great subterranean movements which originally elevated our strata, and from the skill of man in constructing avenues of communication among our most rugged hills, that the mountainous districts of Pennsylvania offer the Geologist a remarkable variety of natural and artificial sections, singularly well adapted for supplying accurate data for Geological measurements, and for facilitating the collection of an ample and continuous series of specimens for illustrating our mineral resources. In many cases a stream passing out of one longitudinal valley to enter another parallel with it, flows through some notch by which the dividing chain of hills, or mountain ridge is cleft to its very base, while, as if to assist still better the researches of the survey, some road, canal, or rail road, stinted in room, has caused the aritificial excavation of the strata, hereby presenting the best conditions possible for accurately studying the rocks and their contents, for securing characteristic specimens, and at the same time for affording a *base* for measuring the position and dimensions of every thing contained in the formations.

A close examination of our rocks, performed with the aid of instruments, being thus very practicable at a great number of places, it is contemplated to multiply these minute operations of the survey, so as to extend them, not only to all the formations of the Appalachian region, but to many different places in each formation, for which there exists a peculiar facility on account of the reappearance at the surface of most of the strata in several successive belts as we cross the mountain chain of the State. This is likewise promoted by the many natural transverse sections which each formation presents wherever it re-emerges along a ridge or valley of any considerable length. Comparisons may thus be instituted of the highest practical and scientific importance between different portions of the same group of rocks as seen at various distant points. Thus—should it appear from measurements made of a particular formation in a certain county, that at a given number of feet from the top or bottom, it embraces a regularly stratified bed of iron ore, valued for its excellent properties, it becomes a point of deep interest to ascertain, even with an approximation to accuracy, the distance at which it is likely to be found from the top or bottom of the same formation, should it shew itself in other quarters of the State.

The whole stratum, from a number of examinations made at different points, is perhaps observed to undergo elsewhere, a regular increase or diminution in its thickness; but a chain of such observations will inform us of the *rate* of this change and enable us to judge with tolerable precision of the real situation of the bed of ore, should it still exist in the formation.

Convinced of the correctness of the views here expressed, in regard to the utility of measuring in detail the strata at various exposures, I planned and set on foot the instrumental survey of an extensive series of Geological sections, several of which have been elaborately executed, occupying with the necessary subsidiary explorations a considerable portion of the latter part of the season.

To present a rapid sketch of what has been done in this branch of research, in the several formations composing the region set apart for the past season's operations, it is proper, first to mention, that no suitable opportunity presented itself for attempting any detailed measurements of either the *sandstone* formation at the base of the whole series of our secondary rocks, which rests usually on the flanks and at the foot of the northern ridges of the South mountain, or of the great *Limestone* of the Kittatinny valley, the next stratum in the ascending order.

A minute examination with the aid of instruments, of the next rock, the *Slate* of the Kittatinny valley, was made on the Delaware river, from a point nearly opposite Columbia to the Water Gap; and the same measurements were extended to embrace a complete section of several of the overlying strata, the sandstones and conglomerates of the Kittatinny mountain, as they are displayed in the majestic cliffs of the Water Gap, and the shales and sandstones of the valley beyond it on the north.

A very extensive section has been begun but not completed on the Lehigh, commencing in the neighborhood of Mauch Chunk, with the conglomerate formation, which lies immediately below the coal measures and embracing all the several groups of strata so admirably exposed along the river from that point to the southern side of the Gold notch by which the Lehigh passes through the Kittatinny mountain into the valley to the south. From this line alone, much useful knowledge will be derived. The measurements, and the specimens there collected, will shew the dimensions and composition in this section of the State, of all the strata, composing no less than nine out of the whole thirteen formations, which constitute the Appalachian region of Pennsylvania.

Another continuous section, including almost as large a number of the formations, eight in all, was measured along the east side of the Susquehanna river, starting from the southern base of the Kittatinny mountain, at the upper surface of the slate, or third formation of the series, and extending through Dauphin to the Third Mountain, to the top of the Eleventh rock in the series, or the red shale below the coal. A comparison of this section, with those made across the same belt of strata, at points further east in the State—for example, with that on the Lehigh above spoken of—will present some instructive points of contrast and resemblance.

A highly interesting exposure of the denuded edges of nearly all the middle formations of the series, being exhibited on the western side of the Susquehanna, between Catawissa and Bloomsburg, and extending by Fishing creek and its little tributary, Hemlock creek, into the heart of Montour's ridge, so as to lay bare nearly every stratum included between the lower part of the Fifth formation and the upper part of the Ninth, a line of measurements was here undertaken.

One principal motive for performing this, was to ascertain with precision, the place among the formations of the valuable layer of iron ore for which the neighbourhood in question has become somewhat noted. This section was made to terminate at the junction of Formations No. IX and No. X, at a point near the summit of the Catawissa Mountain; but in order to extend it to embrace the next superior group of rocks, a measurement of these was accomplished where the recent cuttings on the rail road, at its passage through the mountain in the gorge of the Catawissa creek, afford unusually great facilities for the purpose.

In order still more fully to establish a clue to the position of the band of iron ore above mentioned, and to ascertain its range and probable quantity, another shorter section confined to the formation immediately embracing it, was surveyed at a fine exposure of the stratification two and a half miles below Danville, in the cliffs called the Danville Narrows. The data furnished by these investigations, will serve, it is hoped, as an index to point out the position of this ore, and the indications by which it must be traced in the other counties of the Appalachian region of the State. The origin, chemical composition, and some of the Geological relations, thus ascertained, of this remarkable variety of iron ore, will be given in an after part of the present report, my present object being simply to exhibit the nature of some of

the operations of the survey, and the principles and views which induce me to make them an important portion of the work.

In order to make known the true relative situation of the Anthracite coal measures of the State to the other formations which adjoin them, I caused a very complete section to be surveyed, and an ample collection of specimens to be gathered along the Schuylkill river, from near Mount Carbon, through the gaps in the Sharp and Second mountains, to a point within half a mile of Schuylkill Haven. From this section, that on the Lehigh below Mauch Chunk, and that on the Susquehanna near Dauphin, the relations of the Anthracite coal measures to the other formations, and of these to each other, will be satisfactorily seen; but until the proper time arrives for delineating them and the other sections of a similar kind, all of which it is intended hereafter to have engraved, it will be most judicious to omit attempting any minute account of them. With a view to establish in like manner the connection between the anthracite coal measures of the Wilkesbarre or Wyoming basin and the surrounding strata, and also to ascertain in what respects these differ in regard to thickness, composition, and mineral constituents from the strata of the same formations measured at the several points described, on the southern side of the Pottsville basin, a detailed survey was made of the rocks as they are exposed in the long natural section which the north branch of the Susquehanna displays in crossing the south-western point of the northern coal field at Beach Grove. Another was undertaken at the gap which the river makes at Nanticoke, and another at the gap of Salomn's creek, near Wilkesbarre.

Within the coal fields themselves, where such detailed measurements of the strata are of special importance for supplying the data by which particular coal seams may be traced and recognized, a number of complete transverse sections have been surveyed after the same plan. By far the most extensive and elaborate of these, and which has been performed with as much accuracy as the nature of the ground and the developments of the region would admit, embraces the entire width of the southern, or Pottsville basin, at its broadest part. This section, which is more than four and a half miles in length, extends from the Sharp mountain at Pottsville, to the southern slope of the Broad mountain, in a direction very nearly at right angles to the course or bearing of the strata. Wherever the strata along this line were found exposed by either natural or artificial denudation, direct measurements were made at right angles to their gene-

ral bearing, and their dip or inclination carefully ascertained. The distances of the coal beds from certain fixed points, or from one another, were also obtained, either from actual inspection, or from data already in the hands of proprietors.

The same series of rocks and coal beds, whenever it was practicable, were visited and measured in several different places, in order to detect any changes which might occur in their relative thickness, and intervening distances. These measurements were then compared with each other, and the whole finally connected into one system.

In addition to the above labours, the coal mines were personally inspected, and observations recorded regarding their dip, direction, thickness, and the quality of the strata.

Sets of specimens were taken from each coal seam, both of the coal itself, and of its underlying and overlying strata.

Similar measurements, observations, and collections were made along a line crossing the coal region at Tamaqua, on the Little Schuylkill, the investigations here extending to a complete exploration of all the mines that are accessible.

Operations precisely analogous were performed in that part of the coal basin occupied by the Nesquehoning or Room Run mines, belonging to the Lehigh company and also at the vast excavations of coal called the Summit Mines, the property of the same corporation.

From the more backward state of development of the western half of the southern coal basin, fewer accurate measurements there were practicable. A transverse section of the basin on Rause creek, north of Pine Grove, was however surveyed, while many interesting facts, and valuable data concerning the coal seams and the iron ores of this portion of the region were procured.

The utility of a series of detailed measurements of our strata will be obvious, when it is considered, that in conducting such instrumental observations *all* the rocks and mineral deposits of a district, are in turn presented to inspection, so that the *true relative place* and *real dimensions* of the most obscure layer, if its nature justify it, may be definitely attained. Thus, when the measurements of a formation are sufficiently multiplied, *nothing* that constitutes a part of it as a regular stratum, however thin, need escape observation, since its place being already known in relation to that of all the other beds of the group, we are in possession of a clue of the least erring sort to lead us to its discovery. While this is strictly the case, let it be borne in mind, that the mineral deposits of the earth, unlike its vegetable and

animal inhabitants, follow no very constant type, undergoing, though sometimes very gradually, incessant changes, both of composition and external features, so that it behooves us, before we apply in practice any supposed clue which our measurements may have afforded us, to assure ourselves, from an adequate number of instrumental observations, performed over a sufficiently wide district, of the nature and amount of the modifications presented by the strata, that we may make the required allowance in our calculations. Yet thisvery consideration is itself a striking argument in favor of the importance of accurately measuring our formations; for if they vary from point to point in their dimensions and aspect, how shall we guard against the liability of confounding one stratum with another, but by subjecting them at various places to that critical species of comparison which we may institute when we know all the dimensions and have full suites of specimens of the rocks before us. The propriety of this remark is well exemplified in the delusion, which many of the citizens of the State are under, respecting the presence of coal in a group of rocks in which it has no existence, situated several stages below the true coal measures, but where some fallacious appearances of a coal formation prevail. Some useful illustrations of the necessity of tracing the variations in the nature and quality of our rocks and minerals, by means of multiplied measurements, and an ample series of specimens will be offered in a subsequent part of this report.

While the examinations in the field have been thus in active progress, the investigations in the Chemical department of the survey, have also been diligently pursued.

A Laboratory has been provided with the requisite apparatus and agents, and an extensive series of Chemical analyses of the ores, coals, limestones, and other substances of practical importance which had been commenced towards the close of the former season, has been steadily prosecuted during the past year.

TABLE

SHEWING THE ORDER OF STRATIFICATION, GEOGRAPHICAL POSITION, COMPOSITION, AND THE MAXIMUM THICKNESSES OF THE LOWER SECONDARY FORMATIONS OF PENNSYLVANIA, EAST OF THE SUSQUEHANNA RIVER.

Formations in the ascending order.	GEOGRAPHICAL POSITION.	USUAL COMPOSITION.	MAXIMUM THICKNESS.
XIII.	Anthracite coal basins.	Dark blue shales, blueish grey argillaceous sandstones, and coarse quartzose conglomerates, and seams of Anthracite coal.	6,750 feet nearly, at Pottsville. Not yet positively ascertained.
XII.	Sharp mountain, and the other mountain barriers of the Anthracite coal basins.	Coarse quartzose conglomerates, alternating with white and grey sandstones, and occasional thin beds of dark carbonaceous shale.	1,400 feet. Tamaqua.
XI.	Surrounds the mountain barriers of the Anthracite coal basins, usually in a narrow valley, immediately outside of them.	Red shales and soft argillaceous red sandstones, and occasional beds of compact siliceous red and grey sandstones, also a few thin calcareous bands.	2,949 feet. Mount Carbon.
	Second mountain, Peter's mountain, Mahantango mountain, Berry's mountain, Line	White and olive coloured slates, also dark [illegible] conglomerates, alternating	probably 1,000 feet.

CHAPTER III.

AN OUTLINE OF THE GEOLOGICAL STRUCTURE AND MINERAL RESOURCES OF THE NORTH-EASTERN HALF OF THE APPALACHIAN REGION OF THE STATE.

The main intention of the present report being to exhibit a correct picture of the progress made in the Geological Survey of the State during the past year, that purpose would be imperfectly fulfilled, unless I added to the statement just given of the operations of the season, a brief general description of some of the more obvious Geological features of the regions explored. Such a sketch will serve the two-fold end of rendering more apparent the extent to which the survey has already proceeded in establishing many fundamental points in the geology of the State, and of placing before the reader a few of the results, whose useful applications will justify this early mention of them.

Having extended the investigations of the last season in greater or less detail, to all the formations lying between the northern base of the South mountain, and the table lands of the Allegheny mountain; and between the Delaware river from Easton to the northern line of the State, and the Susquehanna from Middletown to Northumberland, an opportunity has been afforded of becoming acquainted with the entire series of strata comprised in this north-eastern half of the Appalachian region of the State.

It will be seen by an inspection of the opposite table, that there are thirteen distinct groups of strata, or formations, in this portion of Pennsylvania, the lowest reposing on the primary or crystalline rocks of the South mountain, and the uppermost consisting of the materials embracing the anthracite coal.

In my first annual report of the formations occurring between the Kittatinny, or Cumberland valley, and the Allegheny mountain, and lying to the south-west of the Susquehanna, it will be remembered that only twelve were enumerated. But the researches therein mentioned did not extend to the formations of the Kittatinny valley, on the southern margin of which I have since found that another rock exists, underlying all those previously recognized which must now be added to the series. A comparison of the temporary classification proposed in the first report with that now offered, will present a want of agreement in two places. In the first place, the rocks described as third and fourth in the former series, are now thrown into one formation, and constitute the fourth of the present classification; and in the second place, the thick and conspicuous conglomerate and coarse sandstone rock which every where underlies both the anthracite and bituminous coal, is made a distinct formation from the coal measures with which I at first united it.

For the present I have studiously abstained from framing a nomenclature for the several formations of the extensive system of rocks here enumerated, preferring (until I become entirely familiar with the many modifications which they undergo in their course through the Appalachian region) to designate them as well by their numerical position, counting from the bottom of the group, as by distinctive features in the rocks, and a reference to their geographical situation. Until a very wide examination of the strata of our mountain series shall have been made, extending indeed to a comparison between the features they assume in our own and in the adjacent States through which they range, it would, I conceive, be premature to affix any other names to them than such as may hereafter be readily superseded. While our researches are pending, no mode of specifying the strata, appears so practically useful as that which expresses the relative situation of each rock to all the others of the region, and none certainly so free from ambiguity, when combined with a reference to their several geographical positions.

FORMATION No. I.

SANDSTONE OF THE SOUTH MOUNTAIN.

In the ascending order, the first formation which we meet with reposing on the primary rocks of the South mountain, (which is generally the south-eastern limit of the Appalachian strata of the State) is a remarkably compact and rather fine grained sandstone, usually white, or of some light shade of grey. It consists almost exclusively of nearly pure siliceous sand, held together, it would seem, rather by a simple, intense adhesion of the grains, than by the intervention of any cement. These grains, in some varieties of the rock, consist of nearly transparent quartz; in other instances numerous black crystalline specks abound, the fragments, apparently, of some of the harder dark minerals of the adjacent primary rocks, from the disintegration of which this formation has evidently derived its materials. Not unfrequently the stratum appears to have undergone a baking from great heat, as shewn by the approach to vitrification of the particles, by the fragmentary condition of the whole mass, by the ringing sound of the rock when struck, its splintery fracture, excessive hardness, and sometimes by a manifest discoloration, such as igneous agency is known to cause.

When thus partially altered, this rock is an extremely good material for roads, possessing the requisite durability, and yet on account of its shattered structure, demanding only a very moderate amount of labour to break it up.

The formation ranges, according to my present belief, from the Delaware, at Easton, more or less interruptedly across the State, to the Maryland line, pursuing an undulating irregular belt, coinciding with the northern and north-western side of the chain of hills most commonly called in this State, the South mountain, the prolongation of the Highlands of New-York, and of the Blue Ridge of Maryland and Virginia. Its usual place is at the base and upon the flanks of the hills, which form the immediate boundary on the south-east of the great Kittatinny valley; but owing to the quantity of loose materials lodged at the foot of this chain, this stratum is only occasionally exposed, rendering its exact course through the country difficult to trace and delineate upon the map. It is met with in a few places apart from the range of hills against which it commonly reposes, occuring even at distances of some miles in the Kittatinny valley, having been thrust

to the surface through the thick overlying limestone formation by the agency of the vast subterranean forces which once convulsed this whole region. In these cases, it almost invariably gives evidence of having experienced an intense heating.

The formation is to be seen on the northern slope of the hill called Marble mountain, near Easton; also in a ridge about two miles east of Allentown, where it plainly exhibits changes of appearance, resulting from great heat, and a violent crushing force. It is seen at a point considerably nearer to the same town, where it has been somewhat extensively quarried to supply a building stone for the fine new bridge just erected over the river Lehigh. For such purposes it would seem to be extremely well adapted, whenever it can be found, as it often is, unchanged by the agency above alluded to. We meet with it again near Metztown; also, in a ridge near Coxtown, and in very regular stratification about three miles from Reading, well exposed by the cuttings on the Philadelphia and Reading Rail Road. Not to attempt at present tracing it in any detail, it may be enough to mention, that it occurs upheaved in a bold ridge at Chicques, on the Susquehanna, a mile and a half above Columbia, and at many points still further to the south-west—thus it is found in the same range at Ege's iron works, seven miles south of Carlisle, and at the gap of the South mountain, on the Chambersburg and Gettysburg turnpike.

The principal uses to which this rock is applicable, have been already mentioned; but I cannot avoid in this place calling attention once more to its fitness as a building stone, the more suitable varieties being sufficiently easy to quarry and to shape, undergoing no action from climate, and possessing, when dressed, a very agreeable light grey aspect.

Notwithstanding the occasional partial vitrification of this rock, at its junction with the primary masses against which it rests, the excessive compactness of structure arising from this source, though a common, is by no means a prevailing character. As soon as we recede from the immediate neighbourhood where the igneous agency is unequivocal, we find the sandstones to become less indurated, so that in many places its texture adapts it excellently for a building stone.

It contains, as far as yet examined in Pennsylvania, very few organic remains, the best defined species discovered in it being a marine plant, indicative of the oceanic position into which the materials of this stratum were originally swept.

I have satisfied myself that this rock is not confined to the Appalachian region of Pennsylvania, but that it possesses a prodigiously extensive range, not only through Maryland and Virginia, but in a

contrary direction through New Jersey and New-York, and I believe beyond those limits, constituting every where the lowermost formation of the wide spread secondary strata which it encirles in a somewhat interrupted belt, following the primary boundary of these rocks from Tennessee to Lake Champlain, and thence north-westward to the northern shores of Lake Huron and Lake Superior.

I have undoubtedly recognized it at many points along the chain of the Highlands in New Jersey and New-York, and consider it identical with the formation which occurs in the north-eastern part of this latter State, and which was described several years since by Professor Eaton, under the name of "*calciferous sand rock.*" It is the same stratum, I am disposed to believe, which Dr. Bigsby has mentioned as existing on the northern side of Lake Huron.* My brother, Professor William B. Rogers, in conducting the Geological Survey of Virginia, has discovered the same formation there, resting upon the western slopes of the Blue Ridge along which he has traced it for a very great distance.

FORMATION No. II.

LIMESTONE OF THE KITTATINNY VALLEY.

The next rock in the ascending order is the very extensive limestone formation which occupies the south-eastern half of the Kittatinny valley throughout its entire course across the State.

In its ordinary aspect this rock is a blue limestone, of a somewhat earthy texture, in general moderately pure, but often containing more or less sand, clay, and oxide of iron, alone or together, in its constitution. Layers of chert, sometimes called flint, are common between its beds. The direct superposition of this formation to the sandstone previously described, is well displayed in the excavation on the Philadelphia and Reading Rail Road, at the end of the Neversink mountain, three miles from the town of Reading. It may be seen in like manner at Chicques ridge on the Susquehanna.

At its south-eastern margin, or where it borders on the base of the South mountain, its general inclination is towards the north-west, in conformity with the dip of the underlying sandstone; but we seldom recede half a mile into the valley before a change of the dip to the south-east occurs, and what is not a little strange, this latter direction, though contrary to that into which we might naturally suppose the strata would be tilted by an upheaving action exerted along the chain

* See transactions of the Geological Society of London.

of the South mountain, is by far the most prevalent inclination of this rock throughout its entire range. Between the Delaware and the Schuylkill there are frequently two, three, or more anticlinal axes, changing the direction of the dip of this Limestone though on its north-western margin, the inclination is towards the north-west, causing it to disappear in regular and orderly arrangement beneath the slate formation that next overlies it. But between the Schuylkill and the Susquehanna, a distance of fifty miles, these two formations observe a contrary or south-eastern dip along their line of contact, giving rise to the curious phenomenon of an *apparent inversion* of the strata; the slate, which was originally the uppermost rock, seeming to disappear beneath the beds of the Limestone which was originally undermost. From this circumstance, and the many indications of great fracture and contortion observable in the Limestone and slate of the Kittatinny valley, it would appear that these rocks are included in the most convulsed tract in all the Appalachian region of the State.

The upheaving forces which have evidently disturbed the strata in various parts of this vast valley, have in several places thrust the subjacent Limestone to the surface within the district occupied by the slate. This is the case in the small isolated limestone tract on the west side of the Delaware, four miles below the Water Gap, the western termination of a long narrow *valley of elevation*, in which the Limestone is brought to view along the Paulinskill in New Jersey.

Another instance of the protrusion of the Limestone rock through the slate, is near Kreidersville, occurring, like the former case, in Northampton county, and a third is on the Little Swatara creek near Jonestown, in Lebanon county.

This truly valuable rock is applicable to many uses, some of them of the very highest importance to the prosperity of the section of the State possessing it.

In regard to the adaptation of the several varieties of this Limestone as a building stone, and to the manufacture of lime for mortar and cements, and for a manure for the soil, some interesting facts will hereafter be submitted when the results of the numerous chemical analysis, now on hand, are sufficiently matured to authorize their publication.

Omitting, for the present, the other topics that suggest themselves in regard to this rock, I may mention, as a matter worthy of present attention, the existence of highly ornamental marbles in various places throughout the formation.

Some very beautifully shaded and variegated marbles, capable of receiving a very fine polish, have, in the course of the past year been brought to light in Lancaster county by some of the inhabitants; and but little doubt is entertained, that quarries may, hereafter, be opened, which will yield slabs and blocks of adequate dimensions, to make these discoveries of considerable importance. It may be of use to mention here, that I consider the Limestone formation of the neighborhood of the city of Lancaster and the adjacent part of the country, to be the same rock as that which lies to the north-west of the South Mountain in Northampton, Lehigh, Berks, Lebanon and Dauphin, and that while a fairer prospect exists of meeting with the fine grained white and variegated kinds that constitute ornamental marble in the more altered part of the formation as it ranges through some portions of Lancaster county, yet sufficiently promising localities have already been explored in the other district to warrant a hope, a least, that marble of more or less excellent quality may be developed there. But numerous examinations and experiments are requisite to test the value of the specimens gathered, and time has not yet been afforded to enable me to report the results.

Iron Ores of the Kittatinny Valley.

The iron ore connected with the limestone formation of the south-eastern side of the Kittatinny valley, claims strongly our attention from its amazing quantity, its wide distribution, its generally very excellent quality, and its great accessibility.

Though very variable in external appearance and structure, this ore belongs universally to that species, called by mineralogists, *brown iron ore:* assuming nearly all of its modifications of form and structure. It is sometimes compact, and occasionally possesses a fibrous crystallization, and then is true brown *hematite;* but a more usual structure is either that of an irregularly cellular mass, or of a concretion composed of numerous parallel cylinders, like icicles or stalactites, in which case it receives the name of *pipe ore.* In chemical composition it is rather uniform, the more usual impurities being Silica, (the material of common sand,) Alumina, (or the material of pure clay,) and more rarely, Sulphur and Manganese.

The richer kinds may be stated to contain, on an average, from 70 to 80 per cent. of the peroxide of iron, equivalent to a little more than 50 per cent. of pure iron in the crude ore.

A few descriptive remarks, referring to two or three of the mines,

will convey a sufficiently correct knowledge of the ordinary conditions under which it occurs.

On the north-western side of the Delaware river, about two and a half miles below Belvidere, a deposit of the ore exists, which is beginning to be somewhat extensively mined. It lies in a yellowish ferruginous clay, amid large detached pieces of limestone, but the diggings have not yet reached the regular strata of that rock. The chief deposit of the ore occurs about forty feet below the surface. In mining it, shafts are sunk until the ore is found, after which the excavation is carried forward horizontally in the ore, which is raised to the surface by a windlass. It consists principally of the porous cellular variety, and of the kind called pipe ore. An impure sandy ochre, and a fine white clay occur with it.

About five miles north-west of Allentown, and three from the river Lehigh, are large deposits of ore, which have been rather actively worked for the last ten or twelve years. The predominant variety here, is the brown hydrated peroxide of iron, though the red oxide is also abundant. True brown hematite, and a variety of jaspery iron ore, are likewise not uncommon. The material in which the ore is imbedded, is a ferruginous clay, resting over the limestone. A white clay, and an impure ochre are also associated as in the case below Belvidere. None of the excavations have yet reached the subjacent rock. The mining is done either by shafts, or when the configuration of the ground permits, by simply quarrying in the open air.

Iron ore is found in moderate abundance, and of excellent quality in the neighborhood of Emau's, five miles south-west of Allentown. It occurs in clay, no rock being very near it. The ore presents fewer varieties in this place than at the mines last mentioned.

About a mile and a half west of Trexlerstown, in Lehigh county, in a tract where the surface of the limestone formation is quite level, there is a very large deposit of iron ore, some of which, without altering its external structure, which is that of the cellular and pipe ores, has passed to the condition of sulphuret of iron, or the common *copperas mineral.* This mine was originally worked for the iron ore which it contains, this being still an object of pursuit; but the person conducting it, finding the good ore to be mixed with a large quantity of the sulphuret of iron, referred to me about three years since, to devise a remedy for the injurious effects of that material upon his ore and was advised to give his attention to it, not as an iron ore, but as a substance well suited for the manufacture of copperas. Since that

time he has sold large quantities of it for this purpose, in Philadelphia, at seven dollars and a half the ton.

The several layers in this mine vary much in their dimensions; but their respective average thicknesses may be stated thus:

Soil - - - - - - - - - -	2 feet.
Brick clay, and gravel - - - - -	25 "
White clay, pieces of slate, and red clay - -	3 "
Very dark clay - - - - - - -	4 "
Iron ore and copperas mineral from 6 to 18 feet	12 "
Ferruginous sand - - - - - - -	2 "
	48 feet.

Generally the pure iron ore, and the sulphuret of iron or copperas mineral, occur separately, or in different layers of the same stratum, the sulphuret in the lowest position.

The ore is of very good quality and of several varieties; among these, are the brown hydrated peroxide, having the forms of compact, cellular and columnar or pipe, ore; and the red hydrated peroxide, the structure and forms of which are no less diversified.

To attempt to specify in this place the very numerous localities in which the superficial appearances indicate the probable existence of more or less extensive deposits, or even to enumerate the many excavations, some of which are quite large, where the ore is daily procured, would be incompatible with the scope of the present report. It may not be amiss however, to mention one or two particulars respecting the manner in which it occurs.

It appears to be a general rule, that by far the largest and most numerous deposits of the ore belong to that half of the limestone belt which is next to the South Mountain. This is, however, not without exceptions, a signal instance occurring in the rich ore tract which lies about five miles north of Allentown, and a little west of the Lehigh, and which is but a short distance south of the northern margin of the Limestone at its junction with the slate.

No part of the whole limestone belt of the valley indicates the presence of so large a quantity of iron ore below the soil, as the district which lies a few miles south-west of Allentown, particularly in the vicinity of Trexlerstown. To allude to the circumstances which usually betoken an abundance of this kind of ore, one of the most obvious, would seem to be considerable depth for the deposit of ferruginous loam, clay, or other earth, resting on the rocks of the district. This will of course be marked by a corresponding evenness of the

surface, for where the strata of the limestone are naked of so many places, it implies that the covering of earth which contains ore can no where be deep. Another very essential condition is, the earth overlying the rocks should have a large amount of the o of iron diffused throughout it. This will shew itself by its cha teristic bright yellow, or yellowish brown, colour. It must be obse however, that the existence of a large quantity of oxide of iron in deeper part of the soil, will very frequently not be perceptible in colour of the surface of the ground, being confined to the lower lay so that much good ore land is often neglected from want of enterp to dig sufficiently deep.

The hydrated brown and red iron ores, of the principal limest tracts of our State, I conceive to have originated almost entirely, fr the filtration of water through deposits of soil rather richly impr nated with the particles of the peroxide of iron. This I think proved, by the peculiar structure of the ore itself, which not only p on the form of stalactites and stalagmites, (concretions of carbonate lime, produced by the dripping of water,) but precisely those slig variations from these forms which ought to arise from the influen of the particular composition of the surrounding material,—clay loam, or sand,—in modifying the manner in which the water wou filter through the mass, and deposit the ferruginous particles.

The earth containing the ore, I suppose to have been a *sedimen* from that mighty mass of waters which evidently once overspread o our formations, and which derived the materials of this deposit, if w judge by their nature, from the subjacent limestone and the contigu ous sandstones. Thus we may at once discern why the largest an richest accumulations of iron ore, are on the side of the valley nex the base of the South Mountain, for all independent Geological evi dence concurs to shew, that the waters which I imagine to have lef this deposit, flowed towards this quarter from the north, while th level of the valley being most depressed on this side, we ought natu rally to look here for the deepest collections of the heavy ferruginou sediments in which the iron ore is principally found.

From the details above given of three or four of the ore deposits in Northampton and Lehigh counties, it appears that the richest collections of the mineral are at a considerable depth below the soil. Though in the cases already cited, the ore does not occur in contact with the underlying rock; instances could be brought from other quarters of the State, where rich masses, surrounded by the ferruginous loam of

clay, lie in the spaces which often separate the disturbed and uptilted strata of the limestone near its surface. These facts, and the obvious origin of the ore by infiltration, suggest strongly the propriety of oftener seeking low down in the earthy deposit for the mineral, and of endeavouring to ascertain previously to commencing an excavation, whether the ground possesses that depth which would appear in general to accompany the larger accumulations of this valuable substance.

The earth resting on the limestone of the Kittatinny valley, contains in many places a variety of clay, admirably adapted for making bricks. The excellence of this brick earth is owing, in part, to the minutely divided condition, and the quantity, of its silica. This, intimately mixed with the argillaceous matter, imparts to the bricks great durability and uniformity of texture, while an adequate proportion of oxide of iron causes an agreeable and very permanent colour. The excellent hue and preservation of the bricks in some of the older houses in Easton, bear testimony to the good quality of the brick, earth of that particular neighborhood.

The remarks which I have here made concerning the great Limestone formation of the Kittatinny valley, have had more immediate reference to the rock as it presents itself between the Delaware and Susquehanna rivers, though they are scarcely less appropriate to other portions of its long range through the same extensive valley, which it pursues south-westward through this State, and Maryland and Virginia, and north-eastward through New Jersey and New-York, to the St. Lawrence. Throughout this whole course, it preserves invariably the same relative position to the long chain of mountains by which it is bounded on the south-east. It sometimes occupies nearly the entire width of the great Appalachian valley, but in general, especially to the north-east of the Potomac, it confines itself to the south-eastern side.

From Lake Champlain the course of the formation is towards the northern shores of Lake Huron, first encircling the elevated region of primary mountains in the north-east quarter of New-York, in a broad zone, the northern half of which passes up the St. Lawrence, while the other approaches, crosses, and again recrosses the Mohawk, passing Trenton Falls, and joining the first belt east of the outlet of Lake Ontario—whence its direction is nearly north-westward to the upper Lakes. In all this long line it accompanies our lowest sandstone, (the "calciferous sand rock" of Eaton,) overlying it, and like

it, dipping commonly inwards from the border of the great basin, along the margin of which it ranges.

This formation is the same as that which, in my first annual report, I called the *Cove limestone*, from its composing a series of valleys in Bedford, Huntingdon and Centre counties, some of which are called Coves. But this name has too local a reference, and I propose to drop it, leaving the framing of a nomenclature for our rocks to a later stage of the survey.

In the Kittatinny valley, in this State, this limestone presents the explorer with very few well preserved organic remains, while it is replete with them at Trenton Falls, in New-York, and at several points in Virginia. Its fossils, however, are more abundant in the Limestone valleys on the north-western side of our Appalachian region. Well defined bivalve shells and zoophytes, characterize it in Morrison's Cove, Kishicoquillas, Nittanny and Nippenose valleys, and the several other valleys in the quarter of the State where this formation exists.

The largest Caves in the Atlantic States are in this formation, but this is not the place to speak of mere curiosities.

FORMATION No. III.

SLATE OF THE KITTATINNY VALLEY.

Ranging parallel with the great Limestone deposit just described, and lying next in order above it, occurs a not less extensive formation of *slate*, usually occupying the north-western half of the Kittatinny valley. These two very thick deposits throughout their whole course from the Delaware to the Susquehanna rivers, pass gradually into each other along their line of contact.

The upper beds of the Limestone partake of the structure and composition of the overlying slate, while the lower beds of this rock, are not only calcareous, but contain numerous distinct bands of moderately pure Limestone. These insulated narrow belts of limestone are subordinate to the slate, along nearly the whole of the central tract of the valley between the two great rivers, but they are most numerous north of the Tulpehocken creek, in Berks and Lebanon counties.

They constitute an important resource to the agriculture of the slate lands of all this range, in which the soil seems specially to require some assistance from lime, the judicious use of which liberally repays the farmer. These patches of limestone have, as far as time would permit, been carefully traced, and will be ultimately

described in detail and delineated on the map. In its ordinary aspect and composition, the slate formation of the Kittatinny valley, which is the third rock in our series, does not differ essentially from the same stratum as it occurs around the margins of the limestone valleys and Coves of Bedford, Huntingdon, Centre and Mifflin counties, and which, in allusion to its usual situation, was called in my last report the *Cove Slate.* The ordinary colours of the rock are black, blue, dark grey, blueish grey, dingy olive, drab, and sometimes yellow; but in its range through the western part of Berks, and across Lebanon, its predominant colours are red, or reddish brown, with interstratified belts of yellow, the whole formation here assuming a considerable resemblance to the red and variegated slates of *Formation* No. V occurring north-west of the Blue mountain.

The formation as a whole varies extremely in the texture of its different strata, some of which are highly fissile slates, admirably adapted tomaking roofing and writing slates, while others are massive strata of coarse grey sandstone, with some thin beds of conglomerate.

That part of this formation which contains slate, adapted to the purposes of commerce, lies in a narrow zone, distant south, from one to three miles from the Kittatinny mountain, running from a point in New Jersey, a few miles east of the Delaware Water Gap, across the Delaware and the Lehigh, to a few miles west of the latter river. It is, however, only in a very limited number of places within this belt, that the rock presents that fortunate union of circumstances which must prevail to adapt it to be quarried with success. Not only must the rock be sound, uniform and compact in texture, easy to cleave in one direction, and tough in every other, and free from any bands (called ribbons) containing sulphuret of iron, which cause its rapid decomposition, but it must lie in a manner favourable for being quarried, with a stream of water passing over the stratum to preserve it moist, and thereby cause it to split with ease and regularity.

These conditions are found very happily combined in the two quarries, which are at present wrought near the Delaware Water Gap.—That on the west side of the Delaware, worked by the Pennsylvania Slate Company, presents some very interesting features. The true stratification of the rock is only detected here, by the difference in colour, caused by numerous very thin layers of from a few lines, to an inch or two in thickness, traversing the rock in lines parallel to each other and at various distances, not generally exceeding, I believe,

two feet. These ribbons denote the direction of the dip of the str being seams of a somewhat different composition from the rest of mass in which they were originally deposited at frequent interv: Between each two of these ribbons the belt of slate is homogeneo or of uniform texture and composition; but a difference in the qual of the slate on the two sides of one of these thin layers is qu common.

When we examine a new surface of the slate, the usual and perm nent colour of which is a dark blueish grey, the hue of these ribbo is nearly black, but on exposure to the atmosphere, they shew aft some time, signs of spontaneous decomposition, and display a whitis efflorescence, which indicates that this part of the slate contains th sulphuret of iron.

These ribbons are therefore carefully excluded from the slates wher they undergo the operations of cleaving and trimming, in their preparation for the market.

At this quarry, the general dip of the strata, as indicated by that of the ribbons, is towards the west-north-west, at an angle of about 30 degrees, the exact course of the beds being north, 34 degrees east.— In the same part of the quarry the dip of the *cleavage planes*, or in other words, of the slates, is towards the *south*, and at an angle of nearly 50 degrees. There is, however, a dislocation or *fault*, traversing the quarry. This is a slide of one part of the stratum upon the other, and is from six to twelve inches wide, being filled with white calcareous spar and fragments of slate. That which is of chief importance, is, that the rock below it has not only a different actual dip from the portion of the stratum above it, just alluded to, and a different direction also in the cleavage of the slates, but a different quality in these slates themselves, those beneath being much superior to those over the dislocation. From this lower part of the quarry, nearly all of the roofing and writing slates are derived. The best school slates are got from belts that lie directly beneath the sparry seam or fault. The direction of the cleavage planes in this portion of the mass is nearly horizontal, while the planes of stratification dip towards the north-west, but at a very moderate angle. The discrepancy between the directions of the cleavage planes above, and below the fault, suggests the probability that the dislocation and slide in the stratum took place after the mass had acquired this remarkable tendency to cleave in a direction oblique to the stratification, for, had the cleavage originated subsequently to the disruption of the rock, we ought to find it maintaining the same direc-

tion, and observing the same features on both sides of the fault. These facts concerning the change in the quality and the position of the slates caused by the dislocation, indicate how numerous and minute the circumstances are which must be attended to by those who enter on the business of quarrying this rock. During the past year 13,500 dozen of school slates have been manufactured at this quarry, and somewhat more than 300 tons of roofing slates; but these amounts would have been much exceeded had not the general inactivity of commercial business operated to reduce the number of the workmen employed.

About a mile south-east of the quarry just described, another has been opened, but it has not been vigorously wrought. That on the opposite side of the river, in New Jersey, is worked, though rather inactively, notwithstanding the excellent quality of the roofing slates procured in it.

The only other considerable quarry at present in operation in the slate belt of this part of the State, is the Union Slate quarry, about one mile west of the Lehigh, and about seven miles north-west of Allentown. The most remarkable feature here, is the parallelism of the cleavage planes of the slates to the plane of the stratification. The dip is towards the south-south-east, at a somewhat variable angle, averaging 15 degrees. Owing to this coincidence of the cleavage with the stratification, the surface of the slates is apt to be slightly undulated. They are esteemed well adapted for roofing, but being hard, they are not sold for writing slates. The hardness of the rock in this quarry I attribute to the high temperature originally imparted to it by a mass of intruded quartz, which has entered it from a deep and heated source within the earth. This injected material has heaved up a portion of the strata into the form of a small anticlinal elevation in the quarry, and has in other respects deranged the dip of the rock. In 1836, there were sent from this quarry, by the Lehigh navigation, 500 tons of roofing slate, sold at eleven dollars the ton.

There is a small quarry which has been occasionally worked, lying about one mile and a half west of the town of Nazareth. Roofing slate was also formerly procured on the east side of the Lehigh, near Kreidersville, in Northampton county.

It is by no means improbable that other points along the same belt of country would reward diligent search by presenting eligible situations for quarries. A few such have yet been seen during the

nvestigations of the survey, but more examination is required befor any publication of the details would be appropriate.

One fact of some interest to those who may direct their attentio to this slate tract is, that throughout nearly its whole course from the Delaware, to within a few miles of the Lehigh, the dip of the cleavage surfaces is towards the south east, and that too independently of the many contortions and changes of dip in the strata themselves of the slate and the adjoining formations.

In the neighborhood of Nazareth, which is on the line dividing the Slate from the Limestone formation, a material is procured, which answers well the ordinary purposes of *black paint*. This appears to be simply a more than usually carbonaceous, black and soft variety of the slate, occurring near the base of the formation a little above its contact with the Limestone. It occurs also further east on the Bushkill, and has been found likewise on the Union canal, in a corresponding situation in the stratum. It requires to be ground in a drug mill, and levigated in troughs by passing over it a stream of water. Thus prepared, it constitutes, when mixed with oil, a very excellent pigment for the exterior of houses, fences and other structures exposed to the weather.

Before closing these details respecting the slate formation of Pennsylvania, two facts of some practical importance deserve mention. One is, that this is the *same formation* which in Oswego county, in the State of New York, furnishes the grindstones for which that section of the country is noted, and which are distributed extensively throughout the Union. These come from near the Salmon river, about ten miles east of the town of Pulaski. The rock is a soft argillaceous sandstone, not unlike many of the softer sandstone beds of the formation in our own State. At several places in the Kittatinny valley, good grindstones are said indeed to have been procured.

It can hardly be doubted that the farmers and others residing upon the formation will find beds of this rock well adapted for making grindstones, if they will make some enterprising trials. Little skill or experience is necessary for testing whether the material is suitable.

The other fact that I would suggest relates to the identity of this formation, with that which extends along the Hudson river from Newburg, nearly to Glenn's Falls, and which furnishes a large supply of grey flag stones, not only to the city of New-York where the material is largely used in pavements, but to many other towns, and lately to Philadelphia. Though the strata of this formation in the Kittatinny

valley are much contorted, and in many places greatly crushed, yet it is obvious that in so extended a range, numerous quarries of excellent flag stone, and, it is believed, of grindstone rock, might be successfully opened.

These suggestions are now made from a sense of the importance to our citizens, and to the public works of the State, of calling attention to many materials which we possess in abundance within our own borders, as the geology of our State plainly shews, but for which we have heretofore been sending to other States, and even to distant countries.

This slate formation of the Kittatinny valley though it extends in a *single* broad zone from the Delaware river to the western side of Cumberland county, appears in Franklin county in two separate and wide belts, which run thence into Virginia. In its course across New Jersey it divides in like manner into two, and sometimes three, parallel ranges, separated by long narrow tracts of the subjacent limestone, which rises to the surface in the form of one or more anticlinal axes.

Before entering the State of New York these belts again unite, and constitute a very broad tract which occupies, three-fourths, at least, of the great eastern valley of that State. Along the central and western portions of that valley, our slate formation ranges to a point somewhere east of Lake George, when coursing south-westwardly it shews itself on the Mohawk for many miles above its mouth, then doubles westward round the ridge of the Little Falls and extends in a north-western direction to the eastern shore of Lake Ontario. In this north-western part of its course, the strata are nearly horizontal, and contain, on the Salmon river, the beds already described as furnishing such an excellent material for grindstones.

In the first annual report on the Geological Survey of New York, the rocks of this formation occurring in that district are called "the grey sandstones and shales of the Salmon river."

Time has only permitted me to institute as yet a single detailed transverse measurement of the thickness of this formation, the results of which must for the present be accepted as only approximately correct in consequence of the obscurity of some of the exposures of the stratum. It was made on the west side of the Delaware river between the bottom of the sandstone of the Kittatinny mountain, (Formation No. IV,) at the Water Gap, and the upper surface of the Limestone, (Formation No. II,) exposed above Dills's Ferry. The thickness of Formation No. III, thus ascertained, is 6,102 feet.

FORMATION No. IV.

SANDSTONES AND CONGLOMERATES OF THE KITTATINNY, OR BLUE MOUNTAIN.

Overlying the great slate stratum above described, and dipping conformably with it, we find in the part of the State immediately referred to in the present report, a parallel formation consisting of heavily bedded sandstones and massive strata of conglomerates more conspicuous for the features they impart to the scenery, than for any considerable amount of practically useful material hitherto discovered to belong to them. These rocks are embraced in the long, narrow, nearly level, and generally single ridge, called the Kittatinny, or Blue Mountain, which stretches continuously from Cumberland county to within a few miles of the Hudson river near Kingston. They consist of massive strata of hard, white and grey, siliceous sandstones, of various degrees of coarseness, and also of ponderous beds of extremely hard quartzose conglomerate, the pebbles of which are often of great size. The finer grained sandstones abound most in the higher parts of the stratum and are identical in general aspect and texture, as indeed the whole of the deposit is, in relative position, with the stratum denominated in my former report, the *white fucoidal sandstone*. The main deposit of conglomerate lies at the base of the formation, resting upon the subjacent slate.

As a group of strata, the whole mass becomes progressively coarser and more varied in composition, as we follow it eastward from the Susquehanna. On the Lehigh and the Delaware it possesses but little of the fine and even texture, and the whiteness and pure siliceous composition which distinguish this rock as it occurs in the ridges in Bedford and Huntingdon counties, (in Tussey's mountain for example,) some portion of which it retains in the Kittatinny mountain near the Susquehanna.

Tracing it toward the Delaware it augments rapidly in thickness: at the Susquehanna this does not exceed about 400 feet, but at the water Gap of the Lehigh it is increased to 2000 feet at least.

Mixed with the quartzose sand and pebbles which constitute the principal mass of this rock, we encounter, especially in the coarse conglomerates near the bottom of the stratum, many rounded pebbles and fragments of the three underlying formations which intervene between it and the primary rocks at the bottom of the series. Thus

we may recognize some of these pebbles to be derived from the lowest sandstone, some from the dark chert, or flint, so commonly imbedded in the strata of the great limestone, of the Kittatinny Valley, and others usually less regularly rounded, from the slates and grey sandstones of the extensive slate formation which these conglomerate strata immediately overlie.

Here then, we have an interesting proof that the materials composing this deposit were swept together by currents that were set in motion across the three lower formations which now occupy the Kittatinny Valley, whose strata were evidently at the same time more or less uptilted and crushed.

That great disturbances of the earth marked the period which closed the formation of the slate and accompanied the production of the overlying conglomerates and sandstones, is apparent from the coarseness of the ingredients in the latter rocks, the promiscuous manner in which they have been swept together, and especially from the suddenness of the transition between the fine grained slate, the sediment of very tranquil waters, and the extremely coarse conglomerate directly in contact with it, the whole aspect of which implies that an enormous mass of sand and gravel derived from strata just broken up, was suddenly strewed into the waters where the slate was forming. But if evidence still more unexceptionable be required of an upheave of the bed of the ancient ocean at the epoch immediately preceding the formation of these rocks, we have it, strikingly exhibited, at the north-eastern end of the formation, where these conglomerates and sandstones occur on the Delaware and Hudson canal near the end of the Shawungunk mountain. They are here displayed near Rondout, resting *unconformably* and with a gentle inclination upon the steeply uptilted, contorted, and disrupted strata of the immediately subjacent slate.

To suggest a useful application which may be made of some of the beds of the Kittatinny conglomerate, and at the same time to prove the importance, when exploring the mineral or geological resources of a region, of embracing as wide a range of observations as possible, I may state, that the somewhat noted Esopus millstones of New York are procured from the formation now before us. The stratum from which they are derived near the Delaware and Hudson canal, is one of the hard quartzose conglomerates in the Shawungunk mountain, which is the same ridge as the Kittatinny, or Blue mountain of Pennsylvania. There is a probability that in some of the

several notches, or water gaps, of the Kittatinny mountain, a material may be found, as well fitted for making millstones, as the rock at Esopus. The researches hitherto made, regarding this point, indicate a sufficiently reasonable prospect of success to induce me to venture on the present suggestion.

The fourth formation of our series has a very extensive range.—Besides composing the entire mass of the Kittatinny mountain throughout its whole length, from the Hudson river to Cumberland county in our State, it forms the mountains nearly continuous with this range, which bound the Kittatinny valley, (or more appropriately the great *Appalachian valley*,) on the north-west, which extend through Franklin county, Maryland and the northern part of Virginia, and constitute many of the loftier ridges south-west of the Susquehanna, and between the line of the Kittatinny mountain and the base of the Allegheny. Though it terminates suddenly towards the north-east within a few miles of the Hudson, which it does not cross, the formation occurs in a district far to the west of this in the neighborhood of Utica, within a few miles south of which place, the stratum may be seen at several points, cropping to the surface with a gentle inclination towards the south-west. Here the total thickness of the formation does not probably exceed fifty feet, and yet in composition and appearance it is identical with the rock, as we behold it in the Kittatinny mountain near the Water Gap of the Delaware river.

The organic remains preserved in this formation are very few; those by which the rock can be most readily recognised by an uninitiated observer are certain species of *fucoides*, an extinct race of marine plants somewhat allied to the modern sea weeds. These are far more rare in the Kittatinny range of the formation than in the other belts of the stratum in the ridges in Bedford, Huntingdon Centre, Mifflin and Juniata counties. I have, however, seen some broad surfaces of the rock at the Delaware Water Gap, covered by their interlaced and curving stems. This fossil not being confined to the formation under consideration, but abounding even more generally, both in this State and in New York in the lower beds of the next overlying deposit, I have discarded the name *fucoidal sandstone*, bestowed on it in my former report, as not sufficiently distinctive.

There is a small and very globose bivalve marine shell, a species of *terebratula*, which is occasionally met with in the finer grained sandstone layers very near the top of the stratum, and which I have

seen as yet in no other rock of our whole group. As far as organic remains apply, this fossil is very characteristic of the formation.

FORMATION No. V.

RED AND VARIEGATED SANDSTONES AND SHALES OF THE VALLEY NORTH-WEST OF THE KITTATINNY MOUNTAIN, AND OF MONTOUR'S RIDGE.

Resting on the previously described sandstones of the Kittatinny mountain, and occupying a narrow belt of country along the north-western base of that ridge, a formation occurs, some of the characteristics of which are very interesting. This rock, which in my last report, I denominated the "variegated calcareous shale formation," when referring to the features which it assumes in the counties of the Appalachian region south west of the Susquehanna, is composed where it occurs in the belt next the Kittatinny mountain, of an uniformly red and slightly calcareous shale, and a more or less argillaceous red sandstone. It agrees very nearly in its ingredients, its red colour and other characters, with the lower division of the more variegated belts of the same deposit which are exposed on the Juniata river, but it is destitute of the many-coloured calcareous shales, and the numerous interposed layers of limestone that occupy the higher part of the mass in that quarter of the State.

These limestone layers have been sought for along the north-western base of the Blue mountain, in that part of the formation most nearly corresponding to their usual position, but they appear to be absent from this southeastern belt. The valuable, and somewhat remarkable, variety of calcareous iron ore which belongs to several of the tracts of the formation in other sections of the State, has been carefully sought in the same range, on the north side of the Blue mountain, and the conviction has arisen that it also does not occur. A description of this ore will be given when I come presently to speak of the features of the formation, on the North Branch of the Susquehanna: in the meanwhile, a brief mention of the range of the less important belt before us will be proper.

It follows the Kittatinny mountain along a narrow valley, usually not more than a mile wide, and often less, lying between the northern foot of the mountain and a low sandstone ridge, and extends thus from Perry county, nearly to the Delaware Water Gap. Its course

thence, is in the same direction across New Jersey and New-York, to its termination a few miles south-west of the end of the Shawungunk mountain. It seems there to thin out and disappear, for it certainly does not cross the Hudson.

The red and variegated sandstones described in the first annual report, on the Geological Survey of New York, and which underlie nearly all the range of counties running westward, from Oneida county, to the Niagara river, belong to the same formation, and bear a very striking resemblance to the strata as they are displayed in our own State.

In the portion of the Appalachian region north-east of the Susquehanna river, and its West Branch, there are but two zones of this Fifth formation; the south-eastern one I have spoken of; the other, which lies in Columbia county, offers some features to which I now direct attention.

The belt now alluded to, occurs along the northern and southern slopes, and ascends in many places to the summit, of a long, narrow, and moderately high hill, which bears the name of Montour's ridge, and which commencing near the West Branch of the Susquehanna, about five miles north of Northumberland, runs nearly due eastward until it meets the bend in the North Branch of the Susquehanna, about two miles below Danville. Thence after curving for several miles a little to the north, the formation extends, steadily declining in altitude, until its strata sink away in a long and low axis, under the overlying formations, about four miles northeast of the town of Bloomsburg.

Throughout this range the beds are very regularly upheaved along a central line, or anticlinal axis, folding over the ridge and resting on its two flanks, with a moderate inclination towards the north and south, rarely exceeding from 15 to 25 degrees.

The lower strata alternate, as they do along the northern base of the Blue mountain, with the uppermost layers of the white and grey sandstones of Formation No. IV. retaining their characteristic chocolate red colour, and distinguished by the profusion of the impressions of *fucoides* upon their surfaces.

In these features they agree with the similarly situated beds, seen at the Lehigh Water Gap, at the Long Narrows on the Juniata below Lewistown, and at various other points throughout the districts where the strata at the base of the formation are exposed.

These may be examined at the southern foot of Montour's ridge, in some deep ravines cut by the streams entering the river near the "Narrows," about two miles below Danville, and in like manner in several places at the gorges of Fishing and Mahoning creeks, in the same ridge.

Above these lower beds, on both sides of the ridge, and also towards its eastern termination, where it is less elevated and steep, there is a rather thick stratum of dull olive coloured and yellowish brown slate, of a more or less sandy texture. Towards its upper part, occur some highly calcareous fossiliferous layers, from a few inches to a foot in thickness, and an interesting bed of iron ore to be presently described. In the upper part of this slate, there are a few calcareous fossiliferous layers, from ten to fifteen inches in thickness, constituting indeed a moderately pure limestone, with thin veins of white calcareous spar.

Over these, there reposes a heavy stratum of *red shale*, usually a little calcareous, and also, slightly siliceous in its composition, its ordinary character, however, being that of a thinly laminated and highly argillaceous rock. Its lower portion includes a few alternating bands of a yellowish green shale, but the upper part is more uniformly red or reddish brown. Towards the top of the stratum, this red shale passes into the next superior formation, (the limestone, which occupies the sixth place in our series,) by numerous layers of dull greenish yellow slates and calcareous shales, which grow more calcareous as they approach the limestone.

The somewhat noted and much prized calcareous iron ore of the formation before us, is merely one of the first mentioned calcareous fossiliferous layers, among the particles of which, the peroxide of iron, which has filtered from the adjoining ferruginous bands of the rock, is copiously disseminated, having taken the place, sometimes in part, sometimes entirely, of the carbonate of lime of the fossils, which has been dissolved out by the same process that has introduced the oxide of iron. This bed of ore occurs in two lines, one on the northern, the other on the southern slope of Montour's ridge and its prolongation to the east of Bloomsburg, dipping regularly with the other strata from the anticlinal axis.—Towards the eastern end of their range these two deposits, after converging and sometimes uniting on the top of the ridge, lose themselves under the red shales of the upper portion of the formation, in the vicinity of Espytown, but going westward they are traceable to a

point a little west of Danville. The ore has not yet been discovered, at any considerable distance beyond this point.

The bed varies in thickness from six inches to two feet, and is not more uniform in the proportion of its oxide of iron.

In some places it seems to thin away entirely, in others, the bed divides into smaller layers which sometimes lose themselves in the contiguous slates. The ore is at present procured in largest quantity from the neighborhood of Hemlock creek, two miles west of Fishing creek, being mined on both sides of the stream, and also on both sides of the anticlinal axis in the northern and southern dipping strata of the ridge. East of Fishing creek, it has not yet been much developed. As far west as Mahoning creek, near Danville, a distance of about twelve miles from Fishing creek, indications of the ore present themselves on both sides of the ridge, though but few excavations have been made in the intermediate tract, owing to the ore here, being more remote from the canal than that on Hemlock and Fishing creeks.

The ore varies materially in different parts of the bed as respects its hardness, composition, and the proportion of its oxide of iron. The purer specimens consist almost exclusively of the per-oxide of iron and the carbonate of lime; these materials presenting the forms and impressions of the various fossils characteristic of the formation.

The siliceous and argillaceous ingredients rarely amount to more than fifteen per cent of the mass. The carbonate of lime can scarcely be viewed as an impurity, for this material under some form, usually that of crude limestone, is required in smelting nearly all the ores of iron. In this ore it exists disseminated, and in the most favorable condition of admixture to act as a flux; so that it must be regarded rather as a useful, than a hurtful constituent. It may be stated as a common occurrence, that near the surface of the ground, and for some yards below the immediate out-crop of the bed, the ore, in consequence of the prolonged action of water, trickling through it, and dissolving out its carbonate of lime, is generally soft and of a cellular structure, which is pronounced by those who make use of it to be highly favorable to its ready reduction in the furnace. That which is derived from a greater depth possesses much more compactness, and is both more difficult to be mined, and less rich in iron; and though imbued with a larger amount of the carbonate of lime, serving for a flux, it is by virtue of its greater compactness, less easily converted into the metal. The probability is, that by mixing the two varieties and using

a copious blast, more economical and productive results will be procured than by employing even the richest kind separately.

In excavating the ore, that nearest the out-crop is reached by removing the covering of earth and slate to the depth of a few feet, while the portion lying further beneath the surface, is mined by drifts, or levels, entering the bed at points where some cross valley or ravine gives access to the ends of the strata. The band of ore is penetrated in the direction of its range, or parallel with the course of the stratum in which it lies, with just sufficient deviation from the horizontal line to drain the water from the mine, towards the mouth of the drift. It will become necessary, I apprehend, in order to get access to the ore in some of the middle portions of the belt when it cannot be reached by the mode of mining just described, to approach it by tunnels perforating the overlying strata. This method however, will be found much more expensive in the outset than the present plan by drifts entering at the notches, or depressions in the ridge.

Several points will require to be carefully considered by those who undertake to mine this ore, all of which are embraced in the question, of the depth, beneath its out-crop, to which the stratum may be profitably pursued. Upon this will depend the value of the belts of land along both slopes of the ridge below the northern and southern out-crops of the ore bed. One consideration, limiting the depth to which it can be advantageously worked, is the increasing hardness of the ore as we descend. Another is the seemingly progressive reduction in its richness by reason of the less extensive infiltration of the oxide of iron. And a third is the increased height through which the ore and the water will require to be lifted, whenever the mines shall be carried below the common water level of the country. The daily growing experience derived from the mining operations now on foot, will tend to multiply the data for making a safe estimate of the exact extent to which the buried treasures of Montour's ridge can be pursued. Enough is already known respecting the excellent quality of the ore, the large quantity still readily accessible, and the cheapness of the present modes of mining it, to establish a just confidence in the value of this formation as one of the choicest ore tracts in the State.

There are four furnaces which rely on the two or three mines at present in existence on Hemlock creek, for their main supplies of this ore; two are within seven miles of the ore bed, one is at Berwick, within about twenty miles, but convenient to the canal, and the fourth is at Farrandsville, in Lycoming county, to which the mineral

is transported on the State canals, a distance of one hundred miles, thus affording a strong proof of the high estimation in which this ore is held.

An average specimen of the porous variety taken from the out-crop of the north dipping bed, on the west side of Hemlock creek, afforded on chemical analysis the following composition:

Analysis of the porous variety of the fossiliferous Iron Ore of Hemlock Creek.

Peroxide of Iron	85.10	per cent.
Silica	7.10	"
Alumina	5.00	"
Water	2.10	"
Lime and Carbonic Acid	a mere trace.	
	99.60	

The proportion of *pure iron* in this specimen, is very nearly 60 *per cent.* and it exists almost exclusively in the condition of the Peroxide.

Another specimen selected as representing the average quality of the ore in the lowest levels opened, taken at a depth of about twenty yards below the out-crop was in like manner analysed and exhibits the following results:

Analysis of the compact variety of the fossiliferous Iron Ore of Hemlock Creek.

Peroxide of Iron	61.30	per cent.
Silica	2.80	"
Alumina	a mere trace	
Lime	17.84	"
Carbonic Acid	15.33	"
Water	2.20	"
	99.47	

The proportion of pure iron in this specimen, is about 43 *per cent* the condition in which it exists being that of the Peroxide combined with a small amount of the Protoxide.

With good management it is found that two tons of the ore on Hemlock creek will yield one ton of excellent cast iron, and I have been informed by a proprietor of one of the furnaces using it, that the result is occasionally even somewhat greater.

A section has been elaborately surveyed from the anticlinal axis in Formation No. V. on Hemlock creek, southward, across it and the other overlying formations, as far as the Cattawissa mountain.

Another measured in the narrows below Danville, starting from the upper beds of Formation No. IV. in the flank of Montour's ridge, and crossing Formations No. IV. and No. V. will in conjunction with the first, convey much detailed information respecting the modifications which the strata of this district undergo. They will prove especially useful, by designating the precise position of the iron ore of Formation No. IV. and by exhibiting the character and position of the several rocks both below and above it, every one of which will thus become, when carefully studied, an index to the same kind of ore in other quarters of the State. Upon this section the vertical thicknesses of the formations are as follows:

From the anticlinal axis on Hemlock creek, to Cattawissa mountain.

FEET.	
304.01	from anticlinal axis to iron ore.
257.68	" iron ore to red shale.
1372.66	" commencement of red shale to limestone No. VI.
1934.35	" anticlinal axis to limestone.
981.56	thickness of limestone No. VI.
4471.59	" of slates, shales and sandstones. No. VIII.
258.48	" of alternating beds between No. VIII. and IX.
4172.35	" of shales and sandstones of No. IX.

FORMATION NO. VI.

BLUE LIMESTONE ALONG THE NORTHERN BASE OF THE KITTATINNY MOUNTAIN AND ALONG BOTH SIDES OF MONTOUR'S RIDGE.

The rock which occupies the next place in the series, is a blue Limestone. In those tracts where it is fully developed, it consists of several distinct strata which differ from each other in colour and texture, some of them being remarkable for the variety and the profusion of their fossils.

Between the base of this formation and the upper portion of the immediately underlying "red and variegated sandstone" formation, a somewhat gradual mingling of the characters of the two respective rocks takes place, the lower beds of the limestone being usually more or less argillaceous and even slaty, while the upper layers of the

lower rock are sometimes highly calcareous, including in certain districts regular and well defined deposits of limestone.

The limestone formation now before us occurs in many belts in the south-western half of the Appalachian region of the State. East of the Susquehanna and its West Branch, it shews itself less frequently, the only tracts in this quarter being: first, a thin and obscure stratum, lying usually about one mile north of the Kittatinny or Blue mountain, and stretching from the Swatara creek to the Water Gap of the Delaware river; secondly, a short but broader tract composing the limestone valley of Georgetown on the eastern bank of the Susquehanna river, in Northumberland county; thirdly, a band which emerges from beneath the overlying strata about two miles west of Berwick, and there separates into two belts, which encircle Montour's ridge. The most southern of these, ranges with a gentle south dip to Bloomsburg, crosses Fishing creek near its mouth, and afterwards the Susquehanna at Danville. It next recrosses the river about four miles further west and thence runs towards the West Branch, which it crosses about four miles north-west of Northumberland. The northern zone commencing at the same point west of Berwick, ranges with a moderately gentle northern dip (following usually the course of a valley) along the northern base of Montour's ridge. It passes a few hundred feet to the south of Mooresburg and thence reaches the low grounds above the mouth of Chilisquaque creek, where like the former belt it crosses the West Branch of the Susquehanna.

Besides these several zones of the limestone, all of which have been under careful examination, there are others which also lie east of the West Branch, but which are further to the north, and have not been yet explored.

That each of the belts mentioned consists of one continuous stratum, is placed beyond a doubt by the circumstance, that though often concealed for a mile or more in length by the loose materials of the adjacent ridges, or by a deep alluvial covering near the streams, we seldom fail to trace the rock either by the fragments on the surface or by the solid strata themselves, wherever any transverse valley or ravine crosses the ridges at the base of which the limestone usually ranges. It is equally obvious that all these several ranges are but different outcrops of one widely extended formation, for in every case the limestone occupies precisely the same position in the general

series of our strata, always resting upon the shales of Formation No. V.

An interesting and important general fact concerning this limestone stratum, is its increase of thickness at each successive reappearance, as we recede from the Blue mountain going towards the north-west. In the south-eastern belt, or that which follows the north-western base of the mountain, its thickness probably no where exceeds one hundred feet, and it would be nearer the truth to state its average dimensions at from *forty to fifty feet.* A careful search on the Susquehanna river and for many miles east of it in the range of country where if it exist at all, it ought to shew itself, has served to establish the fact of the total absence of this stratum for many miles along the foot of the Blue mountain, but guided by a knowledge of the position which it should occupy in relation to the other strata, I succeeded in finding it immediately north of the Gap of the Swatara creek. Though at this point it is not more than from twenty to thirty feet thick, and quite impure, from the amount of argillaceous matter in it; yet it is convertible into lime, and will prove a real benefit to the agriculture of the immediate neighborhood. An accurate clue to the position of the stratum being once established, its developement at various other points east of the Swatara soon followed, and I am now enabled to announce my belief that this limestone may be detected from the Swatara creek to the Delaware river, at almost every cross ravine or valley which intersects the base of the sandstone ridge next north of the Blue mountain. Near the Swatara this hill is called Swope's ridge, but it takes several names in different parts of its course, which is not much interrupted from the Susquehanna to the Delaware. The place of the limestone is usually near its southern base, though at a few points between the Little Schuylkill and the Lehigh, and also between the Wind Gap and the Delaware river, it occasionally rises to the summit and even overlaps it on both sides.

The formation evidently augments in thickness as we advance eastward towards the Lehigh, though between the Wind Gap and the Water Gap of the Delaware, in its prolongation by the northern side of Cherry valley, it gives signs of again diminishing and becoming impure and slaty. It is very thin and decidedly argillaceous where it occurs a few miles south of Stroudsburg. North-east of the Delaware Water Gap we have not succeeded in tracing it far, and there would seem to be a strong probability that it does not continue more

than a very few miles in that direction, as the belt of country which ought to contain it in Sussex county, New Jersey, has been more than once explored.

Another limestone very analogous in its general aspect and in some of its fossils, but much thicker, and occupying a somewhat superior position in the series, commences not far from the Water Gap and of course near the termination of the former, and ranges extensively towards the north-east, holding the same relative position to the Kittatinny mountain. It is important that we should not confound these two calcareous formations.

It would be entering too far into details to mention in the present report the numerous points where the limestone stratum constituting Formation No. VI, has already been detected along the several ranges whose general course I have described. I have deemed it of use, thus to draw attention to the regularity with which it ranges, that those who are disposed to convert it into a fertilizer of their soils, or employ it as a flux in their furnaces, may, by a knowledge of its exact relative position to the other strata, readily obtain it.

It may be of service to state, that as a general rule, the lower beds of this limestone, where it adjoins the subjacent red and variegated shales, afford a lime in which the chief impurities are clay and oxide of iron, while the upper strata being contiguous to an overlying sandstone, yield a material more or less sandy. Thus it is often practicable with very little difficulty, to select such portions of the formation for quarrying, that the quality of the lime shall be adapted to the peculiar nature of the soil which it is intended to fertilize, or of the ore which it is designed to flux. The two belts of this limestone ranging along the sides of Montour's ridge and thence nearly to Berwick, are the only ones to be found for many miles north or south, and lying as they do, near to the North Branch canal, they furnish a source of lime of great importance to a long and wide tract of country, embracing the Wyoming valley.

Iron ore would appear to prevail very generally in the soil covering this limestone. It possesses all the characters of the ore which I have mentioned in my former report as belonging to the same formation in its various belts throughout the counties lying south-west of the Susquehanna in the Appalachian district. Thus it occurs in some abundance at Bittenbender's, five and a half miles south-west of Stroudsburg, and exists also, though not yet found in much quantity, near the western end of Montour's ridge.

This ore is almost invariably of a light brown, approaching to a chesnut colour, and has a uniform, compact and rather argillaceous texture. Having examined it at a great number of points on both sides of the Susquehanna river, it is yet doubtful whether it occurs in sufficient amount at any one place along the limestone belts described in this report, to become extensively useful.

About three or four miles north-east of Northumberland a deposit of *bog iron ore* occurs, connected apparently with this formation. Though the excavation has not yet proceeded far enough to determine its actual thickness, the superficial extent has been proved to be considerable, and should it on trial be found to make good iron, it may become very useful for mixing with the rich calcareous ore of Montour's ridge.

Though this formation, and as I shall presently shew, the sandstone which overlies it, terminate towards the north-east near the Water Gap of the Delaware, they both occur in numerous interesting ranges extending in the opposite direction as far as the interior of Virginia, and probably beyond.

From measurements made on Fishing creek across that belt of the limestone which ranges along the southern side of Montour's ridge, its thickness at that place is 900 feet very nearly.

FORMATION No. VII.

SANDSTONE OF THE FIRST RIDGE NORTH OF THE KITTATINNY MOUNTAIN.

Overlying the limestone just described, the rock which comes next in order in the series, is a white and yellowish white sandstone, which, in its ordinary aspect, especially in the lower beds, is a coarse and rather loosely cemented aggregate of nearly pure siliceous sand. In the layers next to the limestone, when that formation is present, the composition of the rock is slightly calcareous, as shewn by the mode in which the weather acts upon it.

Its most characteristic feature is an abundance of definitely formed cavities, which are the hollow moulds of various kinds of fossil shells and other organic remains which have at one time existed in this sandstone, but which the porous structure of the rock has enabled the water long since to dissolve and carry away. These easily recognized pits occur only in certain beds, and are not equally plenty in every portion of its extensive range. They are not as numerous in proportion to the thickness of the stratum, in the belt which lies immediately

north of the Blue mountain, as in some of the other tracts further towards the north-west.

Contrary to the rule observed by the underlying limestone in passing through its gradations of thickness, this sandstone appears to be most massive in the belt nearest to the Kittatinny mountain, or more properly in the south-western portion of it, near the Susquehanna river. In the ridge which crosses the river about half a mile north of the Blue mountain, its strata are well exposed for examination and measurement, being in a nearly vertical attitude. Their thickness at this point is about 700 feet. In this quarter, the rock is more compact, and of a greyer colour, and a closer and finer texture than in most of the other districts, and it contains fewer fossil impressions. These, however, are not entirely absent, but exist, though sparsely, in certain layers, which as usual are among the coarsest in the formation. Tracing it eastward, we find it in Swope's hill, near the Swatara, greatly reduced in thickness, and possessing its ordinary texture and aspect. In some of the beds south of Pine Grove, the rock encloses a multitude of the hollow pits, attributable to various species of marine remains, some of the distinctive features in whose structure, are easily discernible. In its course towards the north-east, the out crop of this rock, except when cut down to the common surface by some denuding action, occupies invariably, a steep and ragged ridge, distant from half a mile, to more than a mile, from the Blue mountain. Extending towards the Delaware with a slowly diminishing thickness, it seems to vanish entirely before reaching the Walpack bend of the Delaware river, about sixteen miles above the Water Gap.

In several parts of this range, especially those adjacent to the Delaware, the lower portion of the formation near its contact with the underlying limestone, contains thin layers of *chert* or flint, such as form a constant feature in the belts of the stratum more remote from the Blue mountain, particularly in the counties south west of the Susquehanna. On the Lehigh, and also near the Delaware, a similar, rather thick bed of chert, rests upon the upper side of the stratum, lying along the north-western base of the sandstone ridge.

The materials of this formation, though susceptible of few useful applications, are well adapted to various architectural purposes. Some of the strata not only furnish an excellent common building stone, but being massive, and readily quarried and dressed, they are much used in the construction of the canal locks on the Juniata.

One variety of the rock, recognized by its porous structure, its coarse and uniform texture, and its pure siliceous composition, seems to be well suited for the hearths and in-walls of furnaces; its only imperfection as a hearth-stone, being the difficulty sometimes encountered of getting it in masses of sufficient size.

This sandstone formation, with its accompanying chert, borders the little valley of Georgetown, on the Susquehanna, on the north and south sides, in two converging belts. Though the stratum is here much thinner than in the range next to the Blue mountain, its dimensions are nevertheless considerable.

It is evident that only obscure traces of the formation occur on the northern and southern sides of Montour's ridge, where, if it possessed any conspicuous thickness, it could not fail to be distinctly recognized in some of the many transverse valleys which expose the strata in that anticlinal axis.

Occasionally, loose fragments of it are seen on the surface, near the range of each of the limestone belts of that neighborhood, and from the very sandy character of the soil along the same line, it is not improbable that a thin, and perhaps continuous zone of this sandstone, may rest in contact with the limestone, having been, from its easily crumbled nature, worn down and covered by loose materials to a greater depth than the other harder formations adjoining.

FORMATION No. VIII.

THE OLIVE COLOURED SLATE OF THE VALLEY BETWEEN THE KITTATINNY AND SECOND MOUNTAINS.

The formation which next presents itself in the ascending order is remarkable for being one of the most widely diffused of all the strata of the Appalachian region, and for the constancy with which it preserves over a very wide area, the marked peculiarities of its structure, colour, and composition. In the counties especially referred to in the present report, it consists chiefly of an extensive series of alternating strata of dark grey, greenish and olive coloured slates, and soft grey argillaceous sandstones. The lowest beds consist of a nearly black, easily divisible and somewhat calcareous slate, while the grey sandstones abound most in the higher parts of the mass. These upper layers composed of slates and sandstones in frequent alternation and in nearly equal quantity, gradually become as we ascend, first brown and then red, until we cease to distinguish them from the lower beds of the great red slate and sandstone formation immediately above.

All the several varieties of this rock, its slates, sandstones and especially its limestones, where these latter exist, are conspicuous for the profusion of the interesting fossils contained in some of their beds. The whole stratum is more or less calcareous, and this circumstance, together with the quiet condition which appears to have prevailed in the waters during the deposition of this very thick formation, may explain the abundance and variety of the organic remains.

This formation occurs in several very long belts in the region east of the main stream of the Susquehanna and of its West Branch. The most southern range tracing it from this river eastward, occupies the central part of the valley between the Blue mountain and the second or Mahoning mountain as far as the latter ridge extends, which is to the Lehigh river. Thence in a somewhat broader zone it pursues the same general course between the Blue mountain and the base of the Pokono until it meets the Delaware river immediately above the Water Gap. From this point it follows the valley of the same river, the widest part of the belt being on the north-western or Pennsylvania side, and leaves our State at Carpenter's Point to sweep in a long curving tract entirely across New York.

Between the Schuylkill river, and the Easton and Wilkesbarre turnpike, the belt is generally double, a long and narrow zone of the overlying red sandstone beds of Formation No. IX. lying in a trough in the middle of the Mahoning and Fire Line hills, between the northern and southern ranges of the formation.

This Olive Slate formation occurs, again in a tract, of the form of a long and narrow triangle in the northern part of Dauphin county, extending eastward from the Susquehanna at Halifax and contracting to a point towards the sources of Armstrong's creek.

It occupies a considerably larger tract of a somewhat similar triangular shape in the southern part of Northumberland county, enclosing the limestone valley of Georgetown on its western side next the river, and narrowing to a point near Zimmermanstown, in Schuylkill county. Opposite Selinsgrove another long and wide range of Formation No. VIII, encloses another area of the same limestone formation and stretches eastward through the Shamokin and Roaring creek valleys, to within about two miles of the ridges which unite the Cattawissa and Little mountains. It also extends in a still larger and broader double zone along the valley of the North Branch of the Susquehanna, from its mouth to the mouth of the Wapwallopen creek,

the valley of which stream it thence ascends nearly to its source. —The western half of this tract is double, being divided by the long and narrow range of the formations of Montour's ridge, and their continuation eastward to near Berwick. From Montour's ridge, northward to within about two miles of the foot of the Allegheny mountain, a large portion of the country on the eastern side of the West Branch is composed of this formation, where its strata are finely displayed in the passage of the river through the Muncy hills. The great width which this range of the formation exhibits in Columbia and Lycoming counties, is much reduced, after it enters Luzerne, where following its usual northeastward course it passes between the Shickshinny and the Allegheny mountains, and tapers to a point somewhere east of Harvey's Lake. Another belt of the same rock skirts in many places, the northern border of our State, ranging in a nearly east and west direction, and rarely spreading itself more than a few miles to the south of the Pennsylvania and New York line. It is displayed at the Big Bend of the Susquehanna where it presents all its distinctive features.

The more obviously useful materials derivable from this Olive Slate formation, are as far as regards Pennsylvania, rather few, and these occur in relatively inconsiderable quantities. In regard to the *ores of iron* both it and the several overlying formations as high in the series as the conglomerate beneath the coal measures are singularly deficient. In Perry county, near Bloomfield, it does indeed contain a very excellent variety of iron ore, and in considerable abundance. But the circumstances which seem to have given origin to it at that place are somewhat peculiar, and hence this mineral is not to be regarded as generally occurring in the formation. Should the rock elsewhere occur in similar topographical relations to the other underlying strata, similar deposits of the ore will probably be found, which a more detailed examination of some parts of the stratum not yet explored may possibly bring to light.

Some of the layers of this rock from a resemblance in their colour to the shales of our coal measures, and from their containing at times sufficient carbonaceous matter to cause their partial ignition when highly heated, are very frequently mistaken by those who are ignorant of the true relations of our coal bearing rocks, for unequivocal indications of anthracite or bituminous coal. These delusive appearances occur at the Big Bend of the Susquehanna.

No formation of our whole series has seduced so great a number

of persons, into abortive explorations after coal. It may be useful, therefore, to embrace this occasion to state, that I feel satisfied that the formation, wide as is its range, contains no coal, in any part of the United States, and that in Pennsylvania, it occurs by calculation, at a depth, rarely less than 8000 feet below the lowest coal seams of any of our coal regions.

This formation is commonly more or less calcareous, and embraces occasionally very thin, though impure layers of Limestone, in general only a few inches, or at most, two or three feet in thickness.

One of these layers ranges rather interruptedly from Pine Grove across the Schuylkill, and past Orwigsburg to near Lehighton, on the Lehigh. Another is seen a little south of the ridge bounding the Limestone (Formation No. VI.) of the Georgetown valley, on the southern side. A third small bed may be recognized among the strata exposed on the Shamokin creek, in its passage along the base of the Shamokin hills. With particular care in the calcination, the Limestone of some of these bands may be converted into a rather inferior kind of lime; though with a few exceptions, the poor quality and insignificant quantity of this stratum, will not authorize much expense in the attempt.

On the northern branch of the Appalachian creek, there is a hill of considerable elevation, rising on the north side of the stream, and over which the State line crosses. Nearly on the summit of this hill, though rather on the northern declivity, within less than half a mile of the State line, and about a mile and a half from the line of Bradford county, a considerable deposit of limestone occurs, which promises to be very useful to the surrounding neighborhood, as lime is an article much wanted in this region.

It appears to be a mere enlargement of a calcareous band, in No. VIII. covering an area of fifty or sixty rods in length, and six or eight in breadth, having cross joints and being easily quarried. It does not seem to be a very pure carbonate of lime; but is rather siliceous and somewhat ferruginous, and when burned will yield an indifferent lime, of a grey or reddish colour, though for building and agricultural purposes, it will probably be found highly useful in a region where hitherto the lime used, has been obtained from a great distance.

Some parts of this formation, particularly the greenish or olive coloured slates, would seem to contain a small quantity of the oxide of manganese; and accordingly, where the mountain streams traverse

a sufficient surface of these strata, the oxide of manganese, by the disintegration of the rocks, is not unfrequently found in the form of a black heavy powder, in the beds of the rivulets, where it may sometimes be collected in adequate quantity to render it an article of commerce. The oxide of manganese, from this source, can rarely be wholly separated from the earthy impurities with which it is mingled, and hence, as well as from the very low price of the drug, procured so very cheaply as it is from the mines of Europe, it can rarely justify much expense in collecting it. This oxide of manganese is tolerably abundant near Dr. Ball's, about four miles north-east of Milford in Pike county, and at other places in the same region.

Near the base of the olive slate formation, there exists a very interesting and important limestone stratum, stretching over a great range of country, from near the Delaware Water Gap, where it first obscurely shews itself, to the Helderberg mountains, south-west of Albany, and thence by a wide sweep to the westward, across New York to the Falls of Niagara.

From near the Water Gap this calcareous rock keeps the Pennsylvania side of the river to the Walpack bend on the Delaware, where it crosses into New Jersey, which it traverses in the same north-eastern direction as far as Carpenter's Point. Throughout all this part of the belt, the limestone is accessible from either side of the river, and it is to be lamented that so little of the rock is converted into lime by our farmers of Pike and Monroe counties.

This limestone deposit is a source of incalculable benefit to the highly fertile counties in the middle and western parts of New York, through which State it passes in a broad zone, generally bordering the Erie Canal upon the south. Its lower strata furnish the valuable beds of *Plaster of Paris* (or Gypsum,) found at Manlius, Syracuse, Tonewanta creek, and various other places; and from nearly the same part of the deposit is derived an inexhaustible supply of *hydraulic cement.*

Besides these useful materials, the pure limestone beds in the upper portions of the stratum, produce some of the best building stones of that State.

These facts are here briefly announced, because they suggest to us some highly important inquiries in reference to that portion of the formation which enters Pennsylvania, or closely approaches it in passing down the New Jersey side of the Delaware. Have we within our State, or at an accessible distance, the beds of gypsum and ce-

ment which characterize this formation on the Erie Canal? As well as I have yet been able to ascertain, the gypsum deposits would appear not to occur as adjacent even as the Helderberg hills, in New-York.

The great limestone stratum of the middle and western counties of New York, being a member of our olive slate rocks or Formation No. VIII. of the Pennsylvania series, its lower beds partake of the composition of this slate stratum; some of the beds of which, of greater or less thickness, generally lie beneath it. But the olive slate is in many parts of the formation conspicuous for the large amount of the sulphuret of iron in its composition, (having from this character been termed by Professor EATON, who first described it in New-York,) "*Pyritiferous Slate.*"

In accordance with some views of the origin of gypsum, occurring under analagous circumstances in Virginia, first brought to my attention by my brother, Professor W. B. ROGERS, we may conceive a chemical re-action to take place naturally, between the oxygen of the air contained in the water which penetrates the strata, and the sulphuret of iron of the slate, and the carbonate of lime of the alternating calcareous beds. By well known chemical affinities, sulphuric acid will be developed and a union will ensue between this and the lime, forming the sulphuret of lime, or gypsum.

The rain water filtering through the strata and carrying down in solution the carbonate of lime, to distribute it ultimately through the layers of the shale, must greatly promote the process; but it is by no means improbable that the two ingredients furnishing the gypsum have been to a considerable extent deposited together originally, so that the production of this substance may have commenced at a very early epoch.

From the Helderberg hills to the Delaware Water Gap, there would seem to be an absence of this close association of the carbonate of lime and the sulphuret of iron in the formation, for there is no series of alternating beds of the shale and the calcareous rock, such as we witness near Syracuse and other places in New-York. This I have ascertained by examining the base of the limestone formation on the Rondout creek, near the Hudson, and again in many places in New Jersey, pursuing it from Carpenter's Point, by Milford, to the Walpack Bend of the Delaware, and thence into Pennsylvania, and along the same line of strata to the Delaware Water Gap.

Nevertheless I would not wholly discourage a search for gypseous

deposits in the belt of this formation which ranges along the south-eastern side of Monroe county, for though I have but faint hopes of its existence, its discovery would be fraught with such extensive and lasting benefits to all that section of our State, that the mere possibility of finding it is enough to sanction a careful inspection of the strata, along this belt of country. It is my intention to devote some further examination to this matter, during the progress of the survey.

We possess a belt of hydraulic cement near the base of Formation No. VIII. and in a position nearly corresponding to that of the cement beds of New York, though the material seems to wear a somewhat different aspect and composition. It usually lies immediately on the northwestern side of the sandstone ridge, next north of the Blue mountain, and dips generally to the northwest. It occurs near the Lehigh Water Gap at several places in the position mentioned, and also at various points along the same range towards the Walpack bend of the Delaware. Its colour is generally a dark dull blue, or rather a blueish grey, and its texture nearly that of a compact earthy limestone.

The water of the Olive Slate Formation, is apt to be hard and to contain some saline matters, especially sulphates of iron and alumina or in some instances carbonate of lime.

The soil is usually thin and not productive, but carefully tilled with a liberal and judicious application of lime, it is often found amply to repay the toil and enterprise of the farmer.

This formation will be recognised by the description given above of it, and by its relative position to the other strata of the Appalachian series. It forms the principal stratum in many of the valleys in the counties southwest of the Juniata. It may be traced along the entire line of the valley, which lies at the southern and south-eastern foot of the Table Land of the Allegheny mountain, from Luzerne county, to the Potomac river, and its range through Virginia, is even more extensive than through our own State.

The average thickness of the Olive Slate Formation east of the Susquehanna, is probably not less than 4,000 feet, and on the Lehigh, below Mauch Chunk, it materially exceeds this amount.

On the Susquehanna between the Blue mountain, and the Second mountain, it is very nearly 3,500 feet, and on the North Branch of the same river, it measures near Cattawissa, 4,471 feet, shewing a progressive diminution in the magnitude of the formation as we advance towards the west.

FORMATION No. IX.

RED SANDSTONES AND SHALES OF THE SOUTH-EASTERN SLOPE AND BASE OF THE ALLEGHENY MOUNTAIN.

Overlying the olive colored and grey slates and sandstones, described in the preceding section, we observe in many extensive districts of the State, another still thicker series of sandstones and argillaceous shales, very analogous to the previous group in texture and composition, but differing in the one obvious feature of colour, which in the greater part of the formation before us, is a brownish red.

It has been already mentioned that the bottom layers of this group, alternate with the upper ones of the underlying olive coloured series. Indeed many of the intermediate beds shew a dusky brown tint, a mingling manifestly of the colours, distinctive of the two respective formations. In the lower half of the mass, red shales and very argillaceous red sandstones predominate, while the higher parts contain a large proportion of beds of siliceous sandstone, generally reddish or brown, but sometimes grey, greenish grey, and buff coloured. In this half of the formation, the rock which occurs no where in very massive beds, has generally a tendency to divide into thin flagstone strata, of one, two or three inches in thinkness. This is in part, owing to the greater or less quantity of mica in it. The mode in which these sandstones were originally deposited in layers, slightly oblique to the stratification gives it a cleavage, which is not exactly parallel with the true plane of the dip, which is therefore rendered sometimes a little difficult to be traced with scrupulous precision.

As a formation, this series of reddish slates is even more generally deficient in useful minerals, than the olive coloured group immediately below it. It seems to contain some compact red iron ore, especially at certain points in the range which extends along the Allegheny mountain, but no sufficiently rich deposit has yet been developed to justify a more particular mention of it in the present report. A few very promising places have been partially examined, and a clue procured which will assist in tracing the ore hereafter, should its quantity sanction a minute exploration It occurs on Pine creek, Larry's creek and Lycoming creek. Some of the red shales, as at the Blue hill near Northumberland, are occasionally coated with a very thin pellicle of greenish matter, supposed to be carbonate of copper, but no ores

of either that metal or of lead have yet been found, nor do they probably exist in more than very insignificant quantities in this formation, within our State.

Some of the materials of this formation, especially of the higher strata, are well adapted for architectural uses, being durable and easily shaped, though not ornamental as respects their colour. An inexhaustible supply of very superior flagstones for the pavements of towns, might be sent from many quarters of this widely distributed formation.

In regard to the fossils in this rock, a very manifest deficiency is observable, when compared with those in the stratum beneath it.

The change from the more tranquil sediments of the olive coloured rocks below, seems to have been accompanied by the extermination of the greater portion of the inhabitants of the ancient deep in those quarters at least where these red materials were deposited.

Nor do we find any animal organic remains, except in very rare instances in either of the overlying rocks, until we reach the uppermost formation of the entire group of strata, or that including the coal, and then only in the beds composing the bituminous coal measures.

Throughout our American formations generally, the red slates and sandstones, are remarkable for a deficiency of fossil shells, and other marine animal remains.

Near the junction of this formation, with the coarse whitish, and light grey sandstone stratum next above it, the reddish coloured beds are often replaced by yellowish and buff coloured strata, increasing in number as we ascend, and in the south-eastern belts of the formation, the transition from the one rock to the other is marked by beds of coarse red sandstone, containing numerous large white pebbles of quartz, composing a massive conglomerate. This variety is a durable rock, and fit for many purposes of architecture and construction.

It would not be compatible with my present limits to more than hint at the general range of this widely extended formation. Composing as it does in the north-eastern extremity of the State, some high mountain tracts having the same geographical range with some of the Anthracite coal regions, it was formerly, and is even yet, by many, supposed to be connected with a coal formation.

As no coal can possibly belong to this stratum, from its position in

the series, it is the more important to specify in general terms, the mountain belts and districts of country which consist of it.

By far the widest track of this formation is in the counties northwest of our Anthracite coal basins. Thus it composes more than two-thirds of Pike and Munroe, occupying the whole of the broad table land of the Pokono mountain, spreading from its south-eastern base north-westward, as far as the Wyoming and Moosick mountains, and northward, so as to embrace the whole of Wayne, with the exception of the northern end of the Lackawanna coal basin, and a narrow belt of the Olive Slate formation in the northern side of the county. It forms also nearly the entire surface of the county of Susquehanna, excepting a similar zone on the side next the New-York line, and excepting also some high insulated mountain tracts in the prolongation of the Allegheny, as the knobs of the Mahoopeny and Tunkhannock mountains, which are capped by the next overlying formation. It ranges in almost horizontal strata, along the whole length of the Allegheny mountain, from the North Branch of the Susquehanna to the Potomac, in a belt from one to three miles broad, following its southern and southeastern base, and constituting the entire flank of that mountain nearly to its summit.

Another belt leaves the wide broad area of the formation in Pike and Monroe, and passing south-westward along the base of the Pokono mountain, crosses the Lehigh, and thence, in a narrow line, follows the valley, at the southern base of the Mahoning, or Second mountain, to the western side of the Susquehanna. In Perry county this belt expands somewhat in breadth, doubles round the termination of the Cove mountain, and recrosses the Susquehanna at Duncan's Island. It then ascends the valley of Powell's creek, ranging along the northern foot of Peters's mountain, sweeps northward to the southern base of Berry's mountain, along which it ranges in a zone about two miles wide, from near the head of Armstrong's creek, westward across the Susquehanna. It then crosses the Juniata, and pursues the same course, ascending the valley of Buffalo creek for several miles. At the Juniata it curves rapidly back, around the termination of the Buffalo mountain, and runs north-eastwardly, crossing the Susquehanna at Liverpool, and following the northern base of the Mahantango mountain by the valley of the creek of the same name to the junction of that ridge with the Line mountain, a few miles east of Zimmermanstown. Its next course is due westward, down the valley of Schwaben creek, along the southern side of the Line moun-

tain. Passing along the Susquehanna, it penetrates some miles into Union county, where it sweeps back again to assume once more a north-eastern course, encircling the end of the Mahonoy mountain at the river, and ranging along its southern flank and base to the head of Roaring Creek valley. From thence its direction is westward to Northumberland,—the Blue hill, and a tract for some miles westward, being the end of this particular portion of the formation. But doubling round the end of the Cattawissa mountain the belt resumes its north-eastern course along the northern slope and base of the Nescopeck mountain, which it follows nearly to the head waters of the Big Wapwallopen creek, where, folding back once more, to take a westward range, it pursues the southern side of the Wyoming mountain, passing some miles beyond its western termination to the neighborhood of Jersey Town, in Columbia county.—Before reaching so far to the west as this, the belt makes an elbow once more, and folds round the end of the Knob mountain, the prolongation of the united ridges of the Wyoming and the Shickshinny mountains. Thence it ranges in a moderately wide zone, along the north-western side of the Shickshinny mountain, and the ridge continuous with it, and meets near the North Branch of the Susquehanna, the termination of the long belt which ranges along the south-eastern base and flank of the Allegheny mountain, from the southern side of the State to this point. From this place of junction near the North Branch of the Susquehanna, of these two last mentioned and extensive belts of the formation, it spreads in almost horizontal strata over a wide extent of region thro' Wayne, Susquehanna and the north-eastern portion of Bradford counties.

Passing north-westward out of our own State, this Ninth Formation of our series follows the prolongation of the Pokono, thro' Pike county, in a broad and high chain, augmenting in elevation until it reaches its termination in the grand peaks of the Catskill mountain, near the Hudson. The strata from the base of the Catskill mountain to within a few hundred feet of its loftiest summits, through a thickness, probably of 3000 feet, belong exclusively to this formation, while those which crown the highest parts of the mountain are conglomerates referable to the *tenth* member of the series of our Pennsylvanian rocks. This *ninth* stratum is a conspicuous rock, throughout the whole northern frontier of our State, for sweeping round the base of the mountains, near Towanda, at the eastern extremity of the great bituminous coal region, it ranges westward in a broad belt,

parallel to the coal measures on their northern margin, through the northern portion of Bradford, Tioga, Potter, M'Kean, Warren and Crawford counties, and passes thence into Ohio.

Measured at different places near the several anthracite coal basins, the dimensions of this stratum has been ascertained with considerable exactness, and many facts regarding its variations in this respect determined.

The average thickness of the formation must exceed 5000 feet, the greatest magnitude appearing in the belt along the southern base of the second mountain in Northampton, Schuylkill and Dauphin counties, while a gradual abatement is discernable as we pass towards the north-west and approach the Allegheny mountain.

FORMATION NO X.

SANDSTONES AND CONGLOMERATES OF THE SECOND MOUNTAIN AND OF THE SOUTH-EASTERN SUMMIT OF THE ALLEGHENY.

We ascend from Formation No. IX through a series of alternating strata, usually several hundred feet in thickness, comprising red shales and red argillaceous sandstone allied to that formation, and interposed grey sandstones and red and grey conglomerates connected with the heavy overlying deposits of Formation No. X, which formation I now proceed to describe.

The lower portion of the mass includes white and grey siliceous sandstones with interstratified beds of dark bluish and greenish slates, sometimes resembling the shales contigious to coal, by having occasionally sufficient carbonacious matter in their composition to ignite, when highly heated.

The middle and upper strata are alternations of coarse silicious conglomerates and grey, bluish grey, yellowish and white sandstones, including in some districts thin layers of olive colored and black slates.

The principal useful applications of this rock are to the purposes of architecture. Great caution however is requisite in the selection of the particular layers. A too indiscriminate introduction of its various sandstone beds, but especially of its lower strata which alternate with the upper ones of Formation No. IX, has already resulted in the construction of some of our public works, in the destruction of an immense amount of capital to Pennsylvania. From the fact that a portion of its strata resemble in some degree a part of our coal measures, and at the same time, overlie a red shale and sandstone deposit, having a considerable analogy to that beneath the Anthracite

coal basins, a mistaken belief prevails in the minds of many of our citizens that this rock belongs to the genuine coal formation of the State. Explorations in search of coal, sometimes expensive ones too, are almost daily undertaken, incited by visionary hopes which have no better foundation than vague mineralogical analogies and unscientific attempts to identify our strata.

Upon the summits of the Allegheny mountain where the upper surface of this rock immediately adjoins the base of the conglomerate stratum upon which all our coal measures repose, (there being no red shale interposed,) the difficulty of recognizing the true character of this formation is considerably increased, and erroneous anticipations respecting the occurrence of coal in that part of its range are consequently frequent; but unless indeed it be in Virginia, where from the investigations of my brother, Professor W. B. Rogers, it would appear that some small and as yet unproductive beds of coal do really occur in this rock or its equivalent, I entertain no expectation that research will ever develope a profitable seam of either variety of that mineral in this formation.

For the present, a sufficiently correct idea of its range is presented in the following brief enumeration of the mountains and ridges of our State which consist of it.

Commencing our tracing on the southeast, it caps the Big Creek mountain, east of the Lehigh at Mauch Chunk and the Broad mountain a continuation of this, as far westward at least as the Little Schuylkill.

It forms the main summit and northern side of the second mountain from the Lehigh to Perry county, where it composes the Cove mountain. It forms Peters's mountain, Berry's mountain reaching to the Juniata, the Buffalo mountain and its extension the Mahantango mountain; also the Line mountain and the Mahonoy, with its prolongation, the Little mountain: thence it extends along the Cattawissa mountain and its continuation, the Nescopeck mountain, to where this flattens out and joins the Wyoming or Moosick mountain, the whole of which from Wayne county to its junction with the Schickshinny mountain, in Columbia county, consists of this formation. It composes likewise the Schickshinny and its continuation the Lackawanna mountain, encircling through this and the Wyoming mountain, the whole of the Wyoming coal basin. It sweeps north from the eastern part of the Broad mountain, keeping east of the Lehigh, until in the neighborhood of Bear creek, it crosses this river and forms the flattened

table land at the eastern end of the Nescopeck. The southeastern side of the summit of the Allegheny mountain consists also of this rock throughout its entire course from Maryland to the North Branch of the Susquehanna, beyond which I believe the formation is prolonged in the highest summits of the Tunkhannock mountain

This rock occurs fully developed also in Bedford and Huntingdon counties, holding a corresponding position outside of the coal basin of the Broad Top mountain, which it completely encircles, ranging through Sideling hill, Terrace mountain, part of Allegrippus mountain and Harbour mountain, following these ridges in their continuation southward.

The thickness of this formation has not yet been determined, except at a few places in the State. From the measurements that have been made, it would appear to vary from about 2,200 feet, which is nearly its greatest depth in the belts adjacent to the Anthracite coal basins, to a thickness of only a few hundred feet in other parts of the State.

FORMATION No. XI.

RED SHALE OF THE ANTHRACITE COAL REGIONS.

The next formation in the ascending order, is remarkable for retaining its characteristic features and composition with more uniformity than perhaps any other in our entire series.

It consists almost invariably of argillaceous red shales and soft argillaceous red sandstones. Toward the base of the stratum when the materials partake somewhat of the siliceous character of the underlying sandstones last described, it embraces some beds of hard, compact, red sandstone, with occasional alternating layers, of a similar composition, but of a grey colour. Toward the middle of the mass the sandstones are more argillaceous, and softer, but still include beds of the harder gray variety, while the red shale is somewhat less abundant. This mixed character prevails throughout the upper third of the deposit, until we approach the base of the conglomerate stratum above, near which we generally behold a moderately thick alternation of the remarkably dissimilar rocks of the two adjoining formations, the red shales and soft red sandstones being interstratified with coarse grey sandstones and excessively coarse and massive conglomerates.

If much circumspection be used, the middle and lower portions

of the formation may be made to yield very excellent flagstones and building materials, being procurable in masses of very convenient shape and possessing every requisite in respect to compactness and durability.

Many of the beds of this red shale and sandstone series are more or less calcareous, and a few of them are almost enough so to be considered bands of true limestone. The layers of this character closely resemble each other in composition, consisting of a kind of conglomerate formed of small ovate pebbles or kernels of limestone, of a light blueish grey and sometimes a faint greenish or reddish tint, imbedded though rarely in contact with each other, in a paste of soft argillaceous red shale. Occasionally the rock contains such an abundance of these little limestone pebbles which in shape and size are not unlike the smaller sorts of beans, and the cement uniting them is so calcareous that it possesses almost the purity of an ordinary limestone. When of this description it differs but little from common light blue and greenish grey limestones, except in the mottled appearance arising from its pebbles. This least impure variety has in a few instances been calcined, and has been found to afford a lime which though not very pure or white, is yet tolerably well suited for making mortar, though better adapted to the purposes of a manure for the soil.

The external aspect of this calcareous rock is so peculiar that any attentive observer will readily recognise it, even from the foregoing brief description. Its weathered surface possesses a singularly decayed and worm-eaten appearance in consequence of the greater solubility of the calcareous pebbles over the red argillaceous earth surrounding them, causing the outside to be studded with irregular pits from the partial removal of the small lumps of limestone. The inspection therefore of the weather worn exterior will exhibit better than a newly fractured surface, the relative amount of the carbonate of lime, compared with the impurities, in the rock.

The upper part of the formation would generally appear to contain the purest bands of this calcareous rock, but in some places they abound more in the middle and lower portions. For every such conglomerate bed, pure enough to calcine into lime, many will occur much too impure to warrant the experiment.

The thickness of these bands ranges from six feet to a few inches. A layer, pure enough perhaps to afford an indifferent lime, exists on the south side of the second mountain, in the valley of

Tumbling run, three miles east of Mount Carbon. Another lies in the valley of Locust creek, about two miles northwest of Tamaqua, and presents rather better indications. Other beds, probably however much too impure for practical application, occur in the southern part of the Gap of the Sharp mountain, south of Tamaqua. The same rock is found near Mauch Chunk, and near Beach Grove at the western extremity of the Wilkesbarre coal basin. I have met with it tolerably pure in the red shale tract embraced between the Broad mountain and the Mahonoy mountain, not far from the road leading from Pottsville to Sunbury; but one of the purest belts yet examined occurs immediately at the western end of the Mahonoy coal basin in the red shale rocks near the outer base of the Big mountain, immediately at its termination on the Little Mahonoy creek.

I deem the calcareous rock of this last mentioned spot, which may easily be found, to deserve a careful trial by the farmers in its vicinity.

These are a few of the places in which this stratum has been met with. Enough is known to indicate certainly, that each of the anthracite coal basins is encircled by one or more bands of this rock. Whether it exists of sufficient extent and purity to furnish a supply of lime for the agriculture of the red shale valleys contiguous to the coal fields, is a question which further researches in these regions alone can settle. But no pains should be spared to ascertain its real value, since the valleys where it exists, are far remote from the limestone districts of the State.

A very brief description, will for the present, suffice to designate the range of the red shale formation. Encircling in a continuous zone, all the anthracite coal basins of the State, it usually constitutes a chain of deep and narrow valleys enclosed between the ridges of Formation No. X. on the one side, and on the other, those containing Formation No. XII. composing the margin of the coal measures.

The maximun thickness of this formation, occurs apparently, in its southeastern belt or that which ranges along the south side of the southern anthracite coal basin. From accurately conducted measurements made at Pottsville, the depth of the stratum at that place is about 2,949 feet.

FORMATION NO. XII.

CONGLOMERATES AND SANDSTONES IMMEDIATELY BELOW THE COAL MEASURES OF THE ANTHRACITE, THE BROAD TOP AND THE ALLEGHENY COAL REGIONS.

The stratum which occupies the next place in the series, is a group of siliceous conglomerates and coarse siliceous sandstones immediately subjacent to all the coal measures of the State, both in the anthracite and bituminous coal regions. It reposes upon the red shale formation just described, not only around all the anthracite basins, but also around the bituminous coal measures of the Broad Top mountain; while it rests directly on the upper surface of the sandstones of the next lower formation (No. X) along the entire length of the Allegheny mountain, the south-eastern margin of the great western coal field; the red shale deposit not extending that far towards the north west.

Confining the present description to the formation as it underlies the several anthracite deposits of the State, its mineral character which is well marked and liable to but little variation, may be given in very few words. The whole rock which is usually several hundred feet thick, consists of massive strata of coarse quartzose conglomerates, alternating with white, grey and brown sandstones, of rather diversified texture and composition, including occasionally, a few thin beds of dark carbonaceous shale.

The most abundant and characteristic rock is the conglomerate. This occurs in very heavy beds, especially towards the bottom and the top of the formation. Its materials are chiefly pebbles of white quartz with a few interspersed ones derived from the three rocks at the bottom of our series—the sandstone, the limestone and the slate, of the Kittatinny valley. The limestone itself would seem not to have been sufficiently hard to resist the attrition which accompanied the strewing of this enormous bed of shingle over the bottom of the ancient ocean, but the chert or flint belonging to the formation was better able to withstand the abrading action, and its pebbles, therefore, not unfrequently enter into the composition of the rock.

In the conglomerate there is rarely much sand or other finely divided matter separating the pebbles from each other, which are most commonly in close contact, the rock being nothing else than an aggre-

gate of rounded fragments of white quartz varying from the size of a pea to an inch in diameter.

We observe a regular and manifest diminution in the size of the component pebbles and in the thickness of the stratum, as we pass successively from the Sharp mountain on the southern side of the southern anthracite region, to the belts which surround the middle and northern basins. At the same time the materials assume a more uniform size, and the entire mass grows more homogeneous, becoming a nearly pure quartzose conglomerate. In some of the southern belts the pebbles vary in dimensions from the diameter of small shot to that of an orange, which indeed they occasionally surpass.

It is a fact of no small interest, as pointing out the violent action which immediately preceded the deposition of the first beds of coal, that the lowest seam in some places, is in almost direct contact with one of the very coarsest and most heterogeneous of the conglomerate beds of this formation.

It would appear indeed that the violent movements of the earth's surface which were the prelude to that new and remarkable order of things, which gave origin to the coal, and its accompanying strata, throughout the whole wide region embraced by our enormous coal fields, were not wholly terminated when the production of this material commenced. For at various places on the margin of the southern or Pottsville basin, a seam of coal occurs beneath a thick and very massive stratum of the coarsest sort of the conglomerate.

The uses to which this Twelfth Formation of the series is applicable are few. For massive structures such as the embankments and walls of rail roads, the rock of the conglomerate beds is exceedingly well adapted, and many of the finer grained sandstones are very fit for building stones. The compact and purely quartzose conglomerates, when not too coarse, may be converted into *millstones*, some having been occasionally made, it is said, of this rock, on the margin of the northern or Wilkesbarre basin. The material would appear to be not inferior for this purpose to that found at Esopus, on the Delaware and Hudson canal, which belongs to the conglomerates of Formation No. IV. So nearly alike in their constituents and aspect are the two rocks, that it is sometimes a matter of difficulty to distinguish between them.

The maximum thickness of this conglomerate formation seems to occur towards the eastern part of its most southern belt, or that which forms the Sharp mountain. Thus at Tamaqua it is probably not less

than 1400 feet, whereas at Pottsville it is but 1031 feet, and at Pine Grove, considerably less.

Its thickness in the eastern portion of the Middle Anthracite Region has not yet been positively ascertained, but at Girardville it does not probably exceed 800 feet, while towards the western end, at the gap through the Big mountain, traversed by the Shamokin creek, it is about 700 feet. At Nanticoke, on the north side of the Wilkesbarre basin, it measures about 300 feet, and near Beech Grove, at the western end of the same valley, about 200 feet would seem to be the total thickness.

This diminution in the thickness of the formation as we proceed northward and westward, appears to be continued to the coal regions bounded by the Allegheny mountain, for at Towanda where it caps most of the higher mountains and supports a shallow mass of productive bituminous coal measures, the dimensions of this conglomerate do not probably exceed fifty feet.

It is not a little curious that this white siliceous conglomerate underlies not only all our vast bituminous coal region, to which it forms the south-eastern boundary along the Allegheny mountain, and the northern border along the high table land of our northern counties, but it occurs in a similar relative position along the edge of the same great coal basin in its continuation southward through Maryland and Virginia.

FORMATION NO. XIII.

THE ANTHRACITE COAL MEASURES.

I come next to describe in an equally brief manner, the Anthracite Coal Measures. These with the contemporaneous bituminous coal deposits of Broad Top mountain, compose the last produced or uppermost formation of the extensive system of strata occupying the Appalachian region of Pennsylvania. None of the other formations consists of so miscellaneous a group of materials: for these coal measures comprise, besides the beds of anthracite, an extensive series of shales, sandstones and conglomerates in frequently repeated alternations.

Among the coal seams at the base of the series, we often find a conglomerate of the very coarsest sort, identical in all particulars with the rock which characterizes the upper portion of the next underlying formation. This rock marks the gradation from the one set of

deposits to the other and points to the curious fact that the processes which brought together the materials of the coal, commenced before the previous movements that caused the conglomerate, had wholly ceased. This very coarse aggregate has rarely more than one or two coal beds below it, and ascending a little in the series, we find that its place is supplied by thick beds of shale and masses of soft argillaceous sandstone, with occasional strata of coarse siliceous sandstones, some of whose layers have a sprinkling of pebbles which give them the aspect of conglomerates. These pebbles are smaller and more irregular than those composing the rock at the very base of the series. The coal and the slates immediately in contact with the coal, lie interstratified with these numerous coarse beds in an alternating group of great thickness.

Between the conglomerates, or even the coarse sandstones, and the beds of coal, argillaceous sandstones and blue shales are almost invariably interposed. The predominant rock of the upper part of the series is a compact blue sandstone, containing much argillaceous matter and oxide of iron which cause the atmospheric agents to decompose it superficially, and to impart a dingy brown colour, and a tendency to a conchoidal fracture and to a scaling off at the corners.

The shales which are next in importance to the argillaceous sandstones are commonly of a dark blue or blueish grey colour when freshly broken, but many of them by exposure to the atmosphere and to the vicissitudes of the seasons, assume a brownish ochreous hue and crumble rapidly to pieces. Occasionally these shales contain highly ferruginous bands, in some of which occur layers of tolerably rich argillaceous iron ore. In the Anthracite Coal Measures, as a general rule, this ore does not appear to exist in that abundance which it exhibits in many portions of the bituminous coal series north-west of the Allegheny mountain. Its quantity is, however, very considerable, and hopes are entertained that in the course of the enterprising mining operations and the geological explorations now on foot, valuable bands of the ore may be developed.

These blueish shales also contain, though not abundantly, very beautiful impressions of Ferns and stems of Calamites, and in the lower portions of the deposit, the stems and leaves of other curious vegetable fossils, as Lepidodendron, Sigillaria and Cactus.

In the immediate vicinity of the seams of coal, these shales become more or less carbonaceous, and acquire a darker colour and a more purely argillaceous texture. On such, the miners bestow the name

of *coal slates*. These slates it is generally thought differ materially in appearance and composition accordingly as they lie above or beneath the coal seams. The overlying slate often contains innumerable extremely thin sheets of pure anthracite, minutely interlaminated with equally delicate layers of slate. This is technically termed *bone coal*, and is frequently mistaken by the inexperienced for pure anthracite, though it is easily recognised by its tendency to split into thin parallel layers, and by the number of the ferns and other delicate vegetable impressions usually found in it.

The underlying slate on the contrary, is of a much tougher consistency and of a more regular or well defined fracture, breaking into firm splintery masses instead of loosely aggregated scales.

These slates in contact with the coal beds, vary from one to twenty or even thirty feet in thickness, and not unfrequently occupy the entire space between two contiguous coal seams.

It would lead me far beyond the limits which I have assigned to the present brief sketch, to attempt even a general description of the several vast anthracite coal basins of the State. As was intimated in the early part of this report, many portions of these coal basins have yet to be explored in detail; want of time and of adequate assistance, having made it impossible to extend the minute investigations of the survey beyond certain limited districts.

Yet the mass of observations already collected would, if it were expedient to introduce them here, swell this report to more than four times its present magnitude. To be intelligible and really useful, they would require exemplification by geological maps, sections and numerous other drawings, the publication of which at the present time would be premature. I shall therefore postpone giving any systematic description, either general or particular, of these coal regions, and confine myself entirely to two or three insulated topics connected with peculiar features in their structure, which are of a nature to influence the success or failure of mining operations in certain tracts and districts.

When we advert to the usual shape and structure of the several great anthracite tracts of the State, we perceive that they are long and irregular basins which have assumed their form from the elevation on all sides of them, of the underlying rocks of the country in a series of nearly parallel belts, from which the strata dip in opposite directions, or technically, in a series of anticlinal axes. Thus the northern margin of the Pottsville basin and the southern one of the

Beaver Meadow and Mahonoy, or Shamokin basins, are the joint results of the elevation of the rocks below the coal in the intervening tract of the Broad mountain and its spurs; and in like manner, the particular sub-divisions of each basin have been made to assume a similar basin or trough-like form, (or that in which the strata dip from the margin inwards.) in virtue of the same force of upward protusion of the underlying formations, operating to tilt aside the uppermost or coal bearing deposits. This is well exemplified by the manner in which the Wiconisco basin has been severed from the Dauphin county extremity of the great basin of Pottsville, by the elevation of the subjacent rocks along the anticlinal axis, which passes through the country lying between Berry's and Peters' mountains. This axis gradually dying out to the eastward, permits these two mountains to coalesce, bringing together the two red shale valleys on their north and south, and finally, the two coal valleys themselves, near the head waters of the Swatara creek.

Connected with this violent upheaving action of the strata outside of the coal basins, enormous parallel *wrinklings* of the coal measures themselves, have taken place, causing great intricacy in the internal structure of many parts of these regions. This is augmented by the existence of great dislocations, the results of the same subterranean movements.

Directing our attention to the southern or Pottsville basin, for the illustration and application of these facts, let us examine some of the peculiar features which have there arisen from the agencies alluded to.—The most conspicuous point in the structure of this coal valley, and one intimately connected with nearly every other feature which belongs to it, is a remarkable dislocation, which I have proved to extend nearly from end to end of it, ranging a short distance from the northern foot of the Sharp mountain.

The strata giving way along this line through a length of perhaps fifty miles, those on its southern side have experienced an enormous downthrow. At the same time, the rocks of the Sharp mountain through an extent probably of thirty miles, have been heaved towards the north and tossed beyond the vertical position, so that these ponderous conglomerates lean in an inverted attitude on the entire thickness of the coal measures, which must lie buried in a more or less crushed condition for several thousand feet beneath its northern base.

At Pottsville, at Tamaqua and at Pine Grove, the exact position of this great fracture of the strata, has been detected, while ample

and satisfactory evidence has at the same time been collected, which goes to shew that it ranges continuously through the intermediate tracts.

In consequence of the disruption of the coal measures near the northern base of the Sharp mountain and the *overtilting* of its strata, the coal seams which occupy its northern flank and which are several in number, have sustained a greater or less degree of crushing action, the result of a sliding of the beds in the plane of their stratification. Indeed it is not to be supposed that a group of massive strata many thousand feet in thickness, and composed of materials of almost every degree of tenacity known in rocks, could be upheaved from their originally horizontal position and tossed into a vertical posture, and even beyond it, without undergoing much displacement in a direction parallel with the surfaces of the beds. This action resembles the sliding upon each other of the leaves in a ream of paper, when we suddenly elevate one side and permit the parts of the mass to settle into new relative positions.

In a vast pile of stratified rocks, thus disturbed, the greatest amount of movement and consequently, of crushing force, would take place in the *weakest* layers, which in the case of coal measures, would be the beds of the coal itself. At the same time the strata would experience, especially if they were tilted into a nearly vertical attitude, an unequal lateral *bulging*, such as the sheets in the ream of paper will shew, when it is loosely placed on one end and the *lateral* pressure which preserved them in their places removed. Precisely these results are witnessed in the coal measures of the northern slope of the Sharp mountain, where the coal seams in many places exhibit the effects of a rubbing pressure, to an extraordinary degree.

For a great space in one of these, it is difficult to find a mass of coal exceeding a nut in size which does not give proof by its numerous fissures and highly polished surface, that its parts have been violently crushed. The whole mass has a tendency to crumble into small lenticular flakes which, in consequence of the friction which they have undergone, possess a lustre and a colour, somewhat resembling black lead, from which circumstance the bed has acquired the name of the Plumbago Seam. The lateral bulging of the strata is shewn by the variability in the thickness of the coal seams, the roof and floor of the bed approaching sometimes almost to touching, and at others receding to beyond the full space which should divide them. This alternate contraction and dilatation of the layer, occurs not only in

the direction of its range, as may be seen in the horizontal galleries or drifts, but it exists in the opposite direction or that of the dip, and will render it as difficult to mine such seams with success by the method of *slopes* as by that of *levels*. To shew that these yieldings in the strata pervade the Sharp mountain throughout the greater part of its length, it is only necessary to mention that in every few hundred feet a change in the direction or bearing of the rocks is observable; the levels in the several mines which have been worked in the side of this mountain, between Pottsville and Port Carbon, exhibiting very frequently quite a surpentine course, the flexures however, being very gentle.

The variations in the course of the strata are usually embraced between a direction, north sixty degrees east, and one north eighty degrees east, so that any abrupt twist in the range of the rocks cannot occur, except, as in the case opposite Middleport, where the whole mountain as one mass, has been violently dislocated in a direction transverse to the strata.

I would not convey the idea from what has been said, that all the coal in the Sharp mountain is crushed and all its seams irregular.—Even were this the case, it would not follow necessarily, that some portions of them might not well repay the cost of mining, especially on the plan of drifts, entering at the ends of the strata in the gaps which divide the mountain.

It will sometimes happen that a slightly crushed or fragmentary condition in a coal seam, will require less excavation and permit the operations of the miner, if on a moderate scale, to be conducted with more economy. At the same time I would wish distinctly to make known my belief, that throughout this tract of the coal region, the causes alluded to above, must render the business of mining these nearly vertical and overtilted seams, precarious in a high degree.

Tunnels of several hundred feet in length, are occasionally carried through the hard coal measures of this lower portion of the series to gain access to the several thick beds of coal which lie in the side of the Sharp mountain, but they appear invariably, to have been undertaken under a persuasion which has not yet in a single case been realized, that a portion of the formation could be reached, unembarrassed by the features upon which I have just commented. My own conviction is, that those peculiarities in the structure of the Sharp mountain, constitute from their frequency a general rule, having perhaps, a few rare exceptions, which will hardly I conceive, unless

indeed they are distinctly known to be exceptions, justify the expense of mining the coal, in case it must be done by tunneling.

An interesting fact, concerning the changes in the dip of the coal measures included between the Sharp mountain, at Pottsville, and the Broad mountain, goes far to confirm the views here adopted respecting a tossing over towards the north, of the strata on the south side of the dislocation. It refers to the particular form which generally prevails in the anticlinal elevations of the strata in this part of the basin: namely, the greater steepness of the dips on the northern, compared with those on the southern side of these axes. It is a common remark among the miners, that the north dipping seams are steeper than the south dipping ones, and of less continuance. The reason for this is very intelligible if we will advert to the manner in which the forces operated on the strata at the time when they were elevated.

The rising of the underlying formation in the lofty axis of the Broad mountain tilted the coal measures southward, at a considerable angle, over the entire width of the valley, as far as the great dislocation, but the action in that direction must have been met by the far more resistless force exerted by the Sharp mountain, pressed forward and leaning towards the north by its whole momentum and weight, so as to abut against the edges of the fracture. The tendency of this compression from the south, would be to wrinkle the strata, not in symmetrical anticlinal undulations, as we see them in the other basins, but to thrust the upper part of each fold or wrinkle, towards the north, and thus to steepen the northern inclinations more than the southern.

The waves on a surface of water will explain this. When the wind entirely lulls, the slope is equal on both sides of every wave, but when the wind presses strongly from any quarter, the top of each wave is urged forward from the wind, and the inclination on the far or leeward side is considerably the most abrupt. The geological section which has been measured across the basin at Pottsville, shews the existence of at least five important anticlinal elevations or changes of the dip, and it holds true of most of them, that the dips towards the north much exceed those towards the south. This applies even to the axis in Mine hill, which is an anticlinal elevation exposing the uppermost strata of the conglomerates below the coal, occurring at a distance of more than three miles from the dislocation, where the horizontal thrust towards the north must have been exerted.

Undulations in the dip of the coal measures, caused by numerous parallel anticlinal axes, are of frequent occurrence throughout all the anthracite basins. An exact knowledge therefore of their range and magnitude, and of the peculiarities which sometimes attend them, relating for example to the particular direction and character of the fractures and displacements, must prove of great importance to those who embark their capital in mining operations. These displacements though the apparent cause of the intricacy and confusion so common in the stratification of these coal regions, often maintain among themselves certain features in common, which when understood by the miner, may frequently lead in the prosecution of his work to practical views of incalculable advantage. Thus in the vicinity of Pottsville, the intelligent colliers have long been aware of the relative unproductiveness of the north dipping portions of the strata, though from not recognizing the cause, the fact has not been admitted as a general rule to the extent which it deserves, and injudicious enterprizes are therefore often undertaken in total disregard of it. At a later stage of the survey, it is believed some useful generalizations upon this important subject will have been arrived at; for the present I will allude very briefly to one or two, not however of a very local application.

A striking one is, that these anticlinal elevations of the strata rarely observe a direction quite parallel with that of the coal beds themselves. It would appear, that from the neighborhood of Pottsville, eastward, towards Mauch Chunk, the undulations in the dip most usually draw nearer to the Sharp mountain side of the basin as they extend eastward, thus crossing the true course of the coal measures a little obliquely. In the Shamokin basin, or the western half of the great central anthracite region, the reverse would seem to be the case, each conspicuous anticlinal axis shewing a tendency, in running eastward, to approach the northern barrier of that basin.

It is very important, from the great length of the levels and longitudinal galleries in many of the mines, some of them being nearly a mile in extent, to ascertain for each neighborhood, the quarter, whether east or west, towards which these undulations most commonly flatten out and disappear.

The vicinity of Pottsville was alluded to, to shew a peculiar feature of irregularity in the anticlinal axes, consisting in the greater steepness of the north dips compared with the south.

The coal fields at the eastern end of the great middle region, wil

illustrate a very different structure, arising on the other hand from undulations of remarkable symmetry. The whole of this tract consists of a rather high rolling table land, between the summits of the Buck and Spring mountains, the outer barriers of the coal measures. It is traversed longitudinally, or in a nearly east and west direction, by three, and probably in some quarters, four nearly parallel gently swelling ridges, dividing the region into about four very moderately depressed valleys. These valleys are so many almost regularly formed little coal basins, in which the coal measures, as a general rule, have a very gentle dip towards the interior of each basin, or away from the bounding ridges. The ridges contain broad, rounded, obtuse, anticlinal axes, having the dips on both sides symmetrical, and expose across their summits, and on the upper portions of their acclivities, the conglomerate stratum which constitutes the formation beneath the coal. Much capital may therefore be thrown away in explorations for coal upon these ridges, or in the tracts through which their anticlinal axes are prolonged towards the east and west, if due attention be not paid to the structure of the coal field containing these lines of elevation. Some of the valleys on the other hand are richly supplied with coal, two or three of the seams which are those at the base of the formation, being of great thickness though the total depth of the coal measures, when compared with that in several of the other regions is materially less.

Besides these undulations of the dip, and other disturbances which interrupt the regular basin formed arrangement of the coal measures, in lines nearly longitudinal with the course of the strata, there are systems of *transverse dislocations* in many of the basins, less obvious to the explorer and miner, but exercising, if any thing, a still more serious interference with mining operations. To take the southern or Pottsville region for our illustrations, the numerous gaps and notches in the Sharp mountain, which is its barrier on the south, are nearly all of them connected with great fractures, extending *across* the range of the strata. These fractures indeed appear to have caused those gaps or breaches in the mountain by presenting a barrier, broken at various points, to the scooping floods which have swept alike, across our valleys and our loftiest ridges.

A frequent, though not an invariable consequence of these transverse breaks, is the derangement of the regular continuity of the strata on the opposite sides of the vertical plane in which the crush has taken place. The coal measures are thus abruptly broken off or greatly

twisted and thrust out of their usual range, or to use a mining phrase, *horizontally heaved*, to the north or south of their proper position. This is most apt to occur at the streams, many of which flow through transverse valleys caused by the dislocations here spoken of. Seams of coal extensively mined and familiarly known on one side of a rivulet, often thus elude discovery when sought for on the opposite bank.

The successful recovery of these would however be greatly facilitated by a knowledge of the direction and magnitude of the horizontal heaves in each particular neighborhood. That knowledge can only be accumulated by the joint observations of the geologist and the miner, the one devoting himself to the study of all the phenomena which can cast light upon the inquiry, the other treasuring the hints which the first can furnish, and directing his attention to amass as great a variety as possible of local facts, collected from the mines in the course of his subterranean labors.

One of the most obvious of these transverse dislocations crosses the Sharp mountain and the coal measures at Lorberry creek northwest of Pine Grove. East of the gap by which that stream passes through the Sharp mountain, the strata in this southern barrier of the coal field range about south 72 degrees west, and dip in an *overtilted attitude* at an inclination of rather less than 70 degrees southward, while on the west side of the gap, the course of the rocks is south 57 degrees west, their posture being nearly vertical; the whole mountain and the coal measure north of it being at the same time moved or heaved towards the south as much as thirty yards.

It is probable that a fracture of the same kind passes through the gap of the West Branch of the Schuylkill, two miles west of Pottsville for the coal measures which eastward from this neighborhood are traceable with a moderate degree of regularity for several miles, appear no longer in their ordinary range when they are sought for on that stream. On the West Branch of the Norwegian creek, the strata indicate in like manner a displacement from their usual line of bearing, and the efforts to trace some valuable coal seams west of this water have hitherto ended in disappointment. Whether at these supposed cross dislocations of the strata, those on the western side of the line of crush have been heaved southward, as in the instance at Lorberry creek, or northward, is a question, the solution of which, would be fraught with important benefits to that portion of the coal region.

By far the most conspicuous north and south disruption of the coal

measures and their southern conglomerate barrier, is displayed in an enormous dislocation of the entire chain of the Sharp mountain, about nine miles east of Pottsville, by which the whole mass of the mountain on the eastern side of the break has been moved northward through at least one fourth of a mile, throwing of course all the coal seams far out of their regular position.

A very analogous displacement in the same mountain ridge, and on a scale scarcely less considerable, occurs on the southern side of the basin at the Summit Mines of the Lehigh company, where the eastern prolongation of the Sharp mountain has been thrust northward of the western, through a distance of many hundred yards.—This has formed a broad, elevated, plateau, between the two disjoined summits of the mountain from which all the upper coal measures have been swept away and the strata denuded precisely to that fortunate depth, necessary to lay the vast deposit near the base of the series accessible on the surface of the hill. Thus an immense mass of coal has been speard out over a wide space in a nearly horizontal position, disturbed however by numerons sharp east and west wrinkles or parallel anticlinal axes. These undulations point distinctly to the transverse disruption of the mountain and the adjoining coal measures, as the origin of this remarkable table land.

In all the three instances here adduced, of great cross fractures affecting the Pottsville basin, the strata to the *eastward* of the dislocation are thrust forward toward the *north*, and such, though probably liable to many exceptions, would seem to be the general rule in this southern coal region. The numerous gaps and breaks in the line of the Blue mountain or Kittatinny, exhibit very generally a corresponding law.

This is shewn by measurements at the wide gap of the Susquehanna above Harrisburg, and is manifest to the eye in the bold notch called the Water Gap of the Delaware, where the strata that rise into the summit of the mountain on the New Jersey side of the river are thrown several hundred feet to the north of those in a corresponding position in Pennsylvania. I conceive these transverse dislocations to pervade all the great ridges and valleys of our Appalachian region and to be a primary cause of most, if not all, of those deep notches which are known by the name of Water Gaps, and which cleave so many of our high mountain ridges to their very bases.

An interesting generalization and one of some practical importance to the explorer for coal, especially in certain districts, is that which

indicates that *all* the Anthracite Coal Measures of the several basins are but the several portions of *one* great formation, which previous to its elevation from beneath the waters in which its beds were deposited, constituted a single continuous mass of strata. I am led to this inference not merely from general views of geological causation in reference to all our formations, but after a careful comparison between the same parts of the series in each separate basin. Thus the lower coal measures of the Pottsville basin bear a striking resemblance to those in the same position in both the middle and northern coal fields, making proper abatement of course for the progressive changes discernible in all the strata when traced over extensive areas. I will not at present assume it as established, nor even suppose it susceptible of positive demonstration hereafter, that the great coal seam which lies near the base of the coal measures, commonly from the second to the fourth in position above the conglomerate, is one and the same stratum in all the several regions. Many facts however lend a high degree of probability to the conjecture. There being but one seam of such enormous magnitude in each basin, its occuring in the same part of the series, the close resemblance between its neighboring strata when we compare these in the several basins, and the exact identity of the vegetable fossils of the slates, and the want of this identity with those in the higher portions of the mass; all furnish ground for the belief, that this enormous stratum wherever it occurs, is but a remaining part of one originally more widely diffused deposit belonging to all the basins.

Like nearly all the other strata of the entire series of the formations in the quarter of Pennsylvania which embraces the anthracite coal, this seam, considering the thick bed in each basin as the same, decreases in thickness as we follow it toward the north and west. Thus at the great coal quarries called the Summit Mines of the Lehigh company, which are on a terrace on the side of the Sharp mountain, the depth of the deposit including its numerous layers of coal and alternating thin bands of slate is about fifty feet, while that of the corresponding bed on the north side of the same basin both at Pottsville and at the Nesquehoning mines is about twenty-eight feet. In the Beaver Meadow and Hazleton basins its average thickness is about twenty-two feet, which is very nearly that of the corresponding bed at Wilkesbarre and Carbondale in the northern basin. This shews an abatement in its thickness going northward, and making a similar comparison between its diminsions as we successively meet it passing from

the east toward the west in each basin, we perceive a corresponding diminution in the thickness of the mass to take place in that direction also. Thus the thickness at Beaver Meadow somewhat exceeds that at the gap of the Little Mahonoy near the western extremity of the Shamokin basin, while the depth at Wilkesbarre surpasses that at Nanticoke.

In considering the large coal-seam near the bottom of each series of our anthracite strata as belonging to a single stratum, I wish to explain, that I regard these several thick deposits, as formed most usually, by the junction of two or more smaller beds brought together by the thinning out of the interposed layers of slate and sandstone. Thus observation renders it highly probable that the enormous bed of coal at the Summit Mines of the Lehigh company, owes its thickness of more than fifty feet to the coalescing of three or four of the thick and closely adjacent seams to be seen near the bottom of the formation at Tamaqua, about five miles further to the west. With this limitation of my meaning I conceive it probable that the main coal bed near the bottom of each set of coal measures occupies the same or an equivalent position in the strata in all the basins, and that a portion at least of the mass is identical, and was once continuous from one anthracite coal region to the others.

GENERAL OBSERVATIONS.

In taking a general review of the extensive series of our Appalachian formations, now for the first time systematically classified and described, our attention is forcibly arrested by their vast thickness, the immensity of their range, and the inexhaustible stores of mineral treasure which they contain.

From the base of the entire series, where the bottom of the lowest sandstone is in contact with the primary rocks of the South mountain, to the uppermost beds of the Anthracite coal measures, the absolute depth of this enormous group of strata in our counties east of the Susquehanna, cannot be less than *forty thousand feet*. It is worthy of remark, that probably no other district in the entire Appalachian chain, from the Hudson river, to Northern Alabama, presents our American lower secondary rocks on an equally expanded scale, or so admirably developed for Geological investigation.

The gigantic magnitude of the areas, covered by these thirteen formations, may be conceived, when I state that they not only occupy the entire surface of Pennsylvania, with the exception of the corner of the State, southeast of the South mountain, but that with a few interpolated strata, they comprise three-fifths of the territory of the United States, east of the Mississippi.

In an essay still unpublished, but written nearly a year since based in part upon my own personal observations, and in part upon a comparison between these and the numerous insulated descriptions of our rocks, given by various Geologists and travellers, I have attempted, and as I believe successfully, to trace individually, the formations of our great Pennsylvanian series, south westward along the mountains as far as Alabama, and also to identify them in their course across New-York, and the north-western States, and Canada, to the northern shores of Lake Huron and Lake Superior.

Within the whole of this wide expanse of country, researches will develope I conceive but *a single*, though vast group of strata, the successive sediments of one immense ocean, the creations of but one prolonged Geological epoch, commencing almost in the dawn of marine animal and vegetable existence, and terminating with the latest produced deposits of the coal.

Viewing the majestic scale of our formations, and the combined

grandeur and simplicity of structure of the enormous Geological basin which they embrace, we turn with grateful satisfaction, to the peculiar position which Pennsylvania occupies, in this vast area. Lying on the margin of the great secondary basin of the United States, and traversed as it is, for nearly three hundred miles through its centre, by the whole broad beltof the Appalachian or Allegheny chain, in which a system of gigantic anticlinal elevations, brings the entire series of formations, several times in succession to the surface, it holds in combination with western Maryland, middle Virginia and eastern Tennessee, the *key* to the Geology of many of the other States, where but *a part* of the same strata are spread out in a nearly horizontal attitude, and exhibited in but a single belt. But it is especially fortunate as to the part of the Appalachian chain which it includes. Being at the termination of the great mountain axes, which have elevated the strata, it is to the gradual dying out of these undulations towards the north-east, that by preserving the upper deposits from the destructive agency which has swept them away, in the more disturbed portions of the chain, we possess our Anthracite Coal, one of the most inestimable of all the mineral treasures which nature has bequeathed us. The same Geographical position has placed us, in regard to the great basin, precisely where the general structure of the whole can be best observed, the upper rocks including the coal, not passing out of the State towards the northeast, but bending northward and then suddenly turning westward towards Ohio, at the same time that the middle members of this series sweep outside of these as far as the Mohawk, and returning, are recognized along our northern frontier, while those at the base of the formations are beheld encircling these again, and tracing a yet wider curve to run northwestwardly through Canada, and the region of the Upper Lakes. We have thus a cl ıe on the one hand, to nearly the whole Geology of the Appalachian chain south-westward as far as Alabama, and on the other, to that of the greater part of New-York, and the other regions to the northwest and west of us.

I conceive that much valuable information of a practical character will in the prosecution of the Geological Survey of this State, be derived by paying a vigilant regard to the progress of similar research in other States, the correspondence between whose strata and mineral deposits and our own is so striking. For in accordance with the views above adopted, that all the strata hitherto discovered in the great basin of the United States, above the primary rocks as high as

the coal inclusive, constitute but a single group, of which we have the type in the Appalachian region of Pennsylvania developed to an extent nowhere equalled; it must be obvious that we may render subsidiary to our own researches, the explorations made and making in the same formations throughout any portion of the widely expanded area to which so large a part of our own Geology appertains.

But the most interesting of all the considerations connected with our geological position, is the magnificent picture it presents of our resources. Embracing a territory where the upper or coal bearing rocks of the great ancient secondary basin of the continent terminate toward the east and north, the revolutions which have stripped other States of those treasures, have left us in possession of some of the largest and most richly supplied coal fields of which any country can boast. When we regard their immense extent, comprising either the whole or a part of the area of thirty counties out of the fifty-four in the State, and the wide range and great thickness of many of the coal seams, and when we contemplate the amazing variety in the character of the mineral itself, shewing every known gradation from cannel coal to anthracite, fitting it thus for nearly every possible adaptation in the arts or as a fuel, and then turn our attention to the geological and topographical *structure* of the regions, affording a ready access to their most secluded districts, we behold such a prodigality of happy circumstances as may well inspire exultation. It is estimated that the anthracite coal conveyed to market from our mines in the course of the past year, has nearly amounted to Nine Hundred Thousand Tons, yet this large quantity sinks into insignificance when we look at what the coal trade even in the next ten years is destined to become. If we turn to the southern anthracite basin, the present seat of the most extensive mining operations in the State, we behold a mass of coal measures nearly sixty miles in length and two in average breadth, having in the middle an aggregate thickness of good and available coal exceeding probably *one hundred feet.* When we consider that from this basin and its branches, above 736,000 tons have been sent to market in the course of the past year from six districts only, the Nesquehoning, the Lehigh Summit, the Tamaqua, the Pottsville, the Pine Grove and the Wiconisco mines, and when we reflect that nearly all this coal has been taken from the strata above the water level below which hundreds, nay thousands of feet of coal, following the dip of the seams, lie still untouched, we are made aware of the

enormous amount of undeveloped resources in this coal region alone. The valuable mines of Tamaqua, Pine Grove and Wiconisco are only waiting for greater facilities of access to the important markets on tide navigation on the Delaware and Chesapeake to augment by a large amount the annual supply.

The Beaver Meadow, Hazleton and contiguous basins bid fair from the quantity, quality and admirable position of their coal, to become also on a large scale successful contributors to our growing coal trade.

The inexhaustible possessions of the Mahonoy or Shamokin basin, one of the richest and largest of all the Anthracite coal fields of the State are hardly yet developed, but so soon as the contemplated outlets are completed, the resources of this single valley in which much f the coal is of very superior quality, will be acknowledged to form a most important item in the mineral wealth of Pennsylvania.

To all these deposits let us add the vast supplies of coal which fill the large and beautifully constructed basin of Wyoming and the Lackawanna. Here again, when we regard the excellence of the coal, its great abundance, and the admirable position of the region, with a choice of outlets and a boundless market toward the north, we are struck with astonishment at the prospect.

The awakening spirit of enterprise which is beginning to appreciate the riches of our numerous coal fields is also directing itself in part to the other great mineral staple of the State, our iron ore.

Few regions of similar extent in any country possess this invaluable mineral in the quantity and variety under which it exists in Pennsylvania. To say nothing of the abundance of the admirable pipe ores of our limestone valleys, or the equally profuse supply of rich argillaceous ore in the bituminous coal measures west of the Allegheny mountain, and viewing merely the numerous belts of the brown calcareous or fossiliferous ore of our Fifth Formation, what a picture of wealth does this alone present to stimulate to the cultivation of the useful manufacturing arts, the active industry of our citizens.

But it is when we consider our various kinds of ore and of coal, under one view, and dwell on their contiguity, their valuable adaptations to each other, and then their exhaustless abundance, that we acknowledge with what a lavish yet studious hand, nature has scattered these two great sources of power, prosperity and wealth through Pennsylvania.

CONCLUDING REMARKS.

In my first annual report I made allusion to the glaring defectiveness of the present State Map of Pennsylvania, drawing attention to the impediments which its gross errors place in the way of accurate geological investigation, and mentioning the impracticability of delineating, with any approach to truth, the boundaries of the strata and the position of their mineral deposits after research has ascertained them. In the parts of the State to which the examinations of the survey during the past year have been more particularly confined, the topography of the map appears to be especially erroneous, a fact to be the more lamented, as great advantages would arise to the anthracite regions of the State, were it practicable to exhibit upon the map an exact representation of the intricate features of this highly important division of our Geology.

Should the Legislature at some future day provide for the construction of an accurate Map of the State by instituting a Trigonometrical and Topographical Survey, the results would be fraught with extensive benefits to almost every branch of public and private enterprize, and would reflect lasting credit on the practical wisdom o. Pennsylvania.

All which is respectfully submitted.

HENRY D. ROGERS.

PHILADELPHIA, January 27th, 1838.

GLOSSARY

GEOLOGICAL AND OTHER SCIENTIFIC TERMS EMPLOYED IN THIS REPORT.

EXTRACTED FROM LYELL'S PRINCIPLES OF GEOLOGY.

Alluvium. Earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas. *Etym. alluo*, to wash upon.

Anticlinal Axis. If a range of hills, or a valley, be composed of strata, which on the two sides dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs facing the south, the slates represent inclined strata dipping north and south, and the ridge is an east and west anticlinal axis.

Argillaceous. Clayey, composed of clay. *Etym. argilla*, clay.

Bitumen. Mineral pitch, of which the tar-like substance which is often seen to ooze out of the Newcastle coal when on the fire, and which makes it cake, is a good example. *Etym. bitumen*, pitch.

Bituminous Shale. An argillaceous shale, much impregnated with bitumen, which is very common in the coal measures.

Calcareous Rock. Limestone. *Etym. calx*, lime.

Calcareous Spar. Crystallized carbonate of lime.

Carbon. An undecomposed inflammable substance, one of the simple elementary bodies. Charcoal is almost entirely composed of it. *Etym. carbo*, coal.

Carbonate of Lime. Lime combines with great avidity with carbonic acid, a gaseous acid only obtained fluid when united with water, —and all combinations of it with other substances are called *Carbonates.* All limestones are carbonates of lime, and quick lime is obtained by driving off the carbonic acid by heat.

Carboniferous. A term usually applied, in a technical sense, to an ancient group of secondary strata, but any bed containing coal may be said to be carboniferous. *Etym. carbo*, coal, and *fero*, to bear.

Chert. A silicious mineral, nearly allied to calcedony and flint, but less homogeneous and simple in texture. A gradual passage from chert to limestone is not uncommon.

Coal Formation. This term is generally understood to mean the same as the Coal Measures. There are, however, "coal formations" in all the geological periods, wherever any of the varieties of coal form a principal constituent part of a group of strata.

Conformable. When the planes of one set of strata are generally parallel to those of another set which are in contact, they are said to be conformable.

Conglomerate or Puddingstone. Rounded water-worn fragments of rock or pebbles, cemented together by another mineral substance, which may be of a silicious, calcareous, or argillaceous nature. *Etym. con*, together, *glomero*, to heap.

Crop Out. A miner's or mineral surveyor's term, to express the rising up or exposure at the surface of a stratum or series of strata.

Crystalline. The internal texture which regular crystals exhibit when broken, or a confused assemblage of ill-defined crystals. Loaf-sugar and statuary-marble have a *crystalline* texture.—Sugar-candy and calcareous spar are crystallized.

Denudation. The carrying away by the action of running water of a portion of the solid materials of the land, by which inferior rocks are laid bare. *Etym. denudo*, to lay bare.

Diluvium. Those accumulations of gravel and loose materials which, by some geologists, are said to have been produced by the action

of a diluvian wave or deluge sweeping over the surface of the earth. *Etym. diluvium*, deluge.

Dip. When a stratum does not lie horizontally, but is inclined, the point of the compass towards which it sinks is called the dip of the stratum, and the angle it makes with the horizon is called the angle of dip or inclination.

Encrini. (plural of encrinus) Marine animal bodies, having a long jointed stem, the joints somewhat resembling small buttons with a central perforation. These abound in the lower secondary rocks.

Fault, in the language of miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure, varying in width from a mere line to several feet, which is generally filled with broken stone, clay, &c.

Ferruginous. Anything containing iron. *Etym. Ferrum*, iron.

Formation. A group, whether of alluvial deposits, sedimentary strata, or igneous rocks, referred to a common origin or period.

Fossil. All minerals used to be called fossils, but geologists now use the word only to express the remains of animals and plants found buried in the earth. *Etym. fossilis*, anything that may be dug out of the earth.

Gneiss. A stratified primary rock, composed of the same materials as granite, but having usually a larger proportion of mica, and a laminated texture. The word is a German miner's term.

Gypsum, a mineral composed of lime and sulphuric acid; hence called also *sulphate* of *lime*. Plaster and stucco are obtained by exposing gypsum to a strong heat. It is found so abundantly near Paris, that Plaster of Paris is a common term in this country for the white powder of which casts are made.

Laminæ. Latin for plates; used in geology, for the smaller layers of which a stratum is frequently composed.

Mica. A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. It is often called *talc* in common life, but mineralogists apply the term talc to a different mineral. The brilliant scales in granite are mica. *Etym. mico*, to shine.

Organic Remains. The remains of animals and plants (*organized* bodies) found in a fossil state.

Oxide. The combination of a metal with oxygen; rust is oxide of iron.

Oxygen. One of the constituent parts of the air or the atmosphere; that part which supports life. For a further explanation of the word, consult elementary works on chemistry.

Producta. An extinct genus of fossil bivalve shells, occurring only in the older secondary rocks. It is closely allied to the living genus Terebratula.

Pyrites. (Iron.) A compound of sulphur and iron, found usually in yellow shining crystals like brass, and in almost every rock stratified and unstratified. The shining metallic bodies, so often seen in common roofing slate, are a familiar example of the mineral.

Quartz. A German provincial term, universally adopted in scientific language, for a simple mineral composed of pure silex, or earth of flints: rock-crystal is an example.

Sandstone. Any stone which is composed of an agglutination of grains of sand, whether calcareous, silicious, or of any other mineral nature.

Seams. Thin layers which separate two strata of greater magnitude.

Secondary Strata. An extensive series of the stratified rocks which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called *primary*, and from a third series above them called *tertiary*.

Shale. A provincial term, adopted by geologists, to express an indurated slaty clay. *Etym.* German *schalen*, to peel, to split.

Shingle. The loose and completely water-worn gravel on the seashore.

Silex or Silica. The name of one of the pure earths, being the Latin word for *flint*, which is wholly composed of that earth.

Silicious. Of or belonging to the earth of flint. *Etym. silex*, which see. A silicious rock is one mainly composed of silex.

Stalactite. When water holding lime in solution deposits it as it drops from the roof of a cavern, long rods of stone hang down like icicles, and these are called ***stalactites.***

Stalagmite. When water holding lime in solution drops on the floor of a cavern, the water evaporating leaves a crust composed of layers of limestone: such a crust is called ***stalagmite,*** in opposition to ***stalactite,*** which see.

Strata, Stratum. When several rocks lie like the leaves of a book, one upon another, each individual forms a ***stratum;***—strata is the plural of the word. ***Etym. stratum,*** part of a Latin verb, signifying to strew or lay out.

Strike. The direction or line of bearing of strata, which is always at right angles to their prevailing dip.

Synclinal Axis. When the strata dip in opposite directions ***towards*** a common central imaginary line, it is called a synclinal line or axis.

Thin out. When a stratum, in the course of its prolongation in any direction, becomes gradually less in thickness, the two surfaces approach nearer and nearer; and when at last they meet, the stratum is said to thin out, or disappear.

Zoophytes. Corals, sponges, and other aquatic animals allied to them, so called because, while they are the habitation of animals, they are fixed to the ground, and have the forms of plants. From two Greek words signifying animal and plant.

ERRATA.

Page 17, seventh line from bottom, for "attained" read "*ascertained.*"

Page 35, nineteenth line from bottom, for "when" read "*whence.*"

Page 54, first line in fourth paragraph, for "Appalachian" read "*Apollacan.*"

THIRD ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF PENNSYLVANIA.

BY HENRY D. ROGERS, STATE GEOLOGIST.

READ IN THE HOUSE OF REPRESENTATIVES, FEBRUARY 19, 1839.

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SECRETARY'S OFFICE,
February 19, 1838.

The Hon. WILLIAM HOPKINS,

Speaker of the House of Representatives:

SIR—I have received the third annual report of the State Geologist, which is herewith transmitted in compliance with the acts of assembly on the subject of a geological survey of the state.

And am, respectfully,

FR'S. R. SHUNK,

Secretary of the Commonwealth.

REPORT.

To the Secretary of the Commonwealth of Pennsylvania:

Sir—I beg leave to transmit through you to the Legislature, the following report of the operations of the Geological Survey of the State during the past year.

In accordance with the views set forth and adopted in my two preceding annual reports, I shall confine myself to an account of the progress, which has been made in the field explorations and other work of the survey, and to a general description of the parts of the State which have recently been under examination, intending to reserve as heretofore, the principal portion of the details collected, with the view of submitting them to the public in a more useful and intelligible shape, in a final and comprehensive description of our mineral resources at the close of the investigation.

The requisite time will thus be gained for completing the maps and the numerous illustrative drawings, some of which are now in hand and will be found indispensable to a full and clear understanding of our Geology. Until this species of illustration, so indispensible to a correct idea of the innumerable local details involved in a complete delineation of our formations can be presented, the most copious descriptions must fail to impart more than a very inadequate and erroneous notion of many intricate and curious features connected with the distribution of our strata, and the situation and range of their contained mineral deposits. Between the season, when the specimen of ores, and other materials collected for analysis are gathered in, and the period for presenting the annual report on the survey, the interval is too brief for completing the chemical examinations which are so necessary to a thorough knowledge of their economical value; and this constitutes another reason for omitting numerous minute local references which would possess but half their usefulness if unaccompanied by a statement of the chemical composition of the various substances met with.

CHAPTER I.

OF THE SECTIONS OF THE STATE WHICH HAVE BEEN EXPLORED DURING THE PAST YEAR.

With a view to expedite the Geological survey as far as compatable with accuracy, in the determination and for the purpose of giving to all districts of the State alike the advantages of an early examination, the last Legislature authorized an increase in the number of assistants in the corps, adding aix assistants, and a draughtsman. But little delay has been incurred in procuring individuals of requisite talents to fill the places thus created, and when the spring was sufficiently opened to permit a renewal of our investigations in the field, the corps of assistants was complete, with the exception of two whose services were secured after the lapse of a few weeks.

It now embraces in all, nine Geological assistants, four of whom namely Messrs. HARVEY B. HOLL, ALEXANDER M'KINLEY, CHARLES B. TREGO, and JAMES D. WHELPLEY, hold their places under former acts, the other five namely, JAMES T. HODGE, Dr. JACKSON, JOHN C. M'KINNEY, PETER W. SHAEFFER, and TOWNSEND WARD, having been appointed under the recent law. There are moreover two chemical assistants, Dr. ROBERT E. ROGERS, appointed under the first act and MARTIN BORJE, under the late one.

Greatly aided in my plans for a speedy and general exploration of the State by this important addition to the number of my assistants, I proceeded without delay, to re-organize the operations of the survey so as to extend our investigations to various districts not before examined, and to explore in detail a much larger territory than could have been submitted to observation with the limited number of assistants previously emlpoyed, and what must be considered as of equal consequence, to impart to the developements which are made a proportionately increased degree of success and accuracy.

Previously, our researches had been chiefly confined to one district of the State, namely, that which is included between the South mountain, and the foot of the Allegheny mountain, and between the Susquehanna and the Delaware rivers being directed more particularly to the minute investigation of the several anthracite coal fields. Encouraged, however, by the additional aid provided by the Legislature. I have distributed the corps, as far as practicable over the

whole State assigning a different district to each person, or to two together as the extent and intricacy of the region, or the limited number of the assistants suggested. Accordingly, the whole surface to be explored, was divided into six districts, naturally seperated by the tolerably well marked boundaries both Geographical and Geological.

The *first* of these divisions includes all the counties lying south and east of Kittatiny valley, embracing Philadelphia county, Delaware, Bucks, Montgomery, Chester, Lancaster, York, Adams, and parts of Lehigh, Berks and Dauphin counties. Mr. Holl has assisted in the investigation of part of this region, lying between the Schuylkill and Susquehanna rivers, while Mr. Borje aided me, during a part of the season in the country lying between the Schuylkill and the Delaware. The counties of York and Adams were not embraced in the operations of the season, nor was it in our power to traverse more than about one half of the other counties enumerated.

The *second* district comprises the northeastern part of the Appalachian region of the State, or all that part of our territory which is embraced between the northwestern base of the South mountain, and the southeastern base of the Allegheny mountain, and between the Delaware and Susquehanna rivers, terminating on the latter at Murray creek. This district, the seat of all operations of the previous year had already received a considerable share of investigation, though the amount of time devoted to it had been insufficient for that detailed and thorough examination of the several anthracite basins which these obviously require, both from their pre-eminent public importance and from the minute and intricate relations of their numerous beds of coal. It was deemed advisable, therefore, to continue the work of developing these coal basins, with as large an amount of assistance as the claims of the several other quarters of the State would justify, I accordingly devolved the important task of exploring the southeastern and middle coal regions to Mr. Whelpley, aided by Mr. Sahaeffer, who were facilitated in executing numerous detailed measurements by competent surveyors, whose services were procured for the occasion.

It is conceived, however, that at least another year will be required before a multitude of local points of structure still obscurely understood and upon a precise knowledge of which the successful tracing of the coal must much depend, can satisfactorily be made known

The southwestern half of the Appalachian region, or that included between the Susquehanna river and the state line of Maryland, and between the South mountain and the Allegheny mountaian, constitutes our *third* Geological sub-division of the State, and presents in its complicated topography, and in the numerous rich deposits of iron ore distributed over many of its curiously constructed valleys, a wide field for investigation, requiring close and patient research.—The assistants who have been aiding me in the investigation of this difficult region, are Mr, M'Kinley and Dr. Jackson who during the season have explored in detail, nearly all of that part of the district which includes portions of the counties of Union, Lycoming and Centre.

That important half of the State which is bounded on the southeast by the main ridge of the Allegheny, on the north by the State of New York, and on the west by Ohio, embracing nearly all the bituminous coal fields of Pennsylvania in a series of closely connected basins, was also sub-divided into three districts. These, however, are less distinctly separated by their Geological structure and resources than the division before traced. One of the districts alluded to which I shall call the *fourth* in the State, takes in the whole country between the base of the Allegheny mountain on the southeast and Chesnut ridge or west Laurel Hill on the northwest, extending from the Maryland state line to the Bellefonte and Brookville road. In the arduous task of exploring this very interesting, but wild and forest country, I devolved the details of the examinations upon Mr. Trego, who was aided by Mr. Ward. A large portion of the southern half of this region has been explored, probably with as much minuteness as the wild and wooded character of the surface would permit, while other sections, especially the northern half, will demand a considerable amount of additional research, before a sufficiently clear view of the situation and extent of the mineral wealth of the district can be acquired.

The *fifth* district comprizes nearly all the counties lying west of Chesnut ridge, and of a line prolonged north from its northern extremity along the eastern county line of Armstrong and Venango, and thence through Warren to the state line of New York. In order to secure as speedy as possible a developement of this part of our State so highly endowed as to Geological resources, I divided it for the season into two sections, assigning to Mr. M'Kinney the duty of

aiding me in exploring the southern half and to Mr. Hodge the same duty in regard to the northern portion. In that portion of the district lying south of the Allegheny and Ohio rivers, about one half of the data necessary to a thorough understanding of its economical geology or useful mineral resources have been collected, while (throughout the rest of this extensive western region, a rather less degree of progress has been made) in consequence of my not procuring the services of Mr. Hodge until the two first months of the season had elapsed.

The *sixth* and last division of the State, includes all those parts of Luzerne, Lycoming and Centre counties, which lie north or northwest of the base of the Allegheny mountain, also the northern two-thirds of Clearfield and Jefferson, the eastern half of Warren, and the whole surface of M'Kean, Potter, Tioga and Bedford counties.

The five large sections of the State previously enumerated, engrossed the attention of all the assistants in the survey and a very large share of my own time, the remaining portion of which was spent in parts of the region last designated. It was not practicable, therefore, to undertake during the season a regular survey of the extensive counties in the northern part of the State, which, throughout more than four-fifths of its surface is an unbroken wilderness requiring for the examination of its little known, but inexhaustable resources, a party specially equipped with tents and other accommodations for subsisting in and traversing its dense forests. The extent of my observations in this quarter of the State, have consisted in a personal reconnoisance during a few weeks made in parts of Warren, M'Kean, Jefferson, Clearfield and Centre counties, with a view of ascertaining the best mode of overcoming the peculiar difficulties which the wilderness character of the region presents to accurate Geological researches, and of planning for the future seasons of the survey a systematic exploration of its well stored coal fields. Enough was discovered of the Geological structure and peculiar topography of this portion of country, to enable me to determine upon the most eligible method of conducting a detailed examination, and to authorize the conviction, that the real extent and position of its mineral wealth can be satisfactorily ascertained, within a period as brief as will be wanted for the survey of the other districts of the State.

Many reasons suggested the propriety of distributing the corps of assistants in the manner above designated. It was desirable to afford

to every part of the commonwealth, as far as practicable, the advantages of an early survey of its own peculiar mineral resources, and a simultaneous exploration of several districts is obviously the only mode by which in a limited number of years, the requisite degree of precision can be attained. Each district has a more or less different class of deposits disposed in a special order, not to be witnessed elsewhere; it has also a different topography, which when adequately studied affords often times a valuable clue in tracing its mineral deposits; while on the one hand, it has its peculiar difficulties, that demand much local knowledge to surmount, and on the other features calculated to lead to useful discoveries, if familiarly understood. By alloting, therefore a particular range of country, as far as possible to each individual in the corps, and restricting his explorations to that alone, until he shall have mastered its Geology and mineral resources in all their local details, an important economy of time is effected, and increased accuracy in the results is insured.

Having adopted this system, my own duties have consisted in visiting every district several times in the season, in regular rotation, and in a personally superintending the explorations as they proceed. This plan tends to remove the difficulties in the investigation, as they arise, by contributing the experience and information gained, in the other quarters of the State to any particular problem, to which they may apply. It enables me also without loss of time to institute as when necessary a fresh series of measurements, or if the work be much retarded by local intricacies, such as occasionally occur, to concentrate an increased number of assistants to the point, while thus superintending and directing these investigations, I deem it my duty to review in person every portion of the field explored, which possesses the least share of practical or scientific interest; so as to be able while checking the results of the assistants, to satisfy myself by personal observation of the facts and conclusions with which they continually furnish me.

CHAPTER II.

A GENERAL SKETCH OF THE OPERATIONS OF THE SURVEY IN THE DISTRICTS SOUTHEAST OF THE ALLEGHENY MOUNTAIN.

SECTION 1.

Of the first or southeastern district, embracing the country lying to the southeast of the Kittanning valley.

The southeastern or first district in the foregoing Geological division of the state, comprehend all the region which lies to the southeast of the great limestone belt which ranges through the Kittanning or Cumberland valley, or in other words, it is bounded on the northwest by the northwestern base of the chain of hills called the South mountain. The rocks which appertain to this populous and highly favored section of our state are of several descriptions, as follows: each presenting several varieties and embracing minerals of more or less utility and interest. First, various species of the so called primary stratified rocks, as gneiss, mica slate, talc slate, chrystaline limestone or marble, serpentine, &c.

Secondly, unstratified chrystaline rocks of undoubted igneous origin, as granite and sienite, both of them usually in thin veins, and also greenstone, basalt and other species of trap rock penetrating and overlapping the primary and secondary strata in dykes and ridges of considerable magnitude.

Thirdly, rocks of sedimentary origin of the class called secondary. Some of these claim identity with the lower formations of the great Appalachian series of strata, more fully developed throughout the rest of our state, to the north and west of the South mountain, while others belong to deposites of a somewhat more modern era, their materials having been brought together after the strata, embracing all our coal seams were upheaved to form a part of the dry land. Of the former are the sand stones designated as formation I, of our Appalachian series, these compose a considerable portion of the rocks of the South mountain. Next the limestones or formation II, of the same series; these occupy nearly all the central tracts of Lancaster

county. Lastly, the slaty formation III, identical with the slate rocks of the northwest side of the Kittanning valley, but confined in this district to a few small valleys subordinate to the chain of hills in that part of the range which is east of the Schuylkill river.

The other group of secondary rocks in this district composes red shales, and red and grey sandstones, and several varieties of conglomerate, all belonging to one series of deposites of a date posterior to the coal, and occupying a long and irregular trough extending across the state from Maryland to New Jersey, through the counties of Adams, York, Dauphin, Lebanon, Lancaster, Berks, Chester, Montgomery, and Bucks. To these rocks I propose to give the name, (for convenience sake) of middle secondary strata, in contradistinction to the Appalachian formations on the one hand, which are unequivocally our lowest secondary formations, and on the other hand to the green sand deposites of New Jersey, Delaware and some of the southern states which constitute the uppermost secondary strata of our country.

The primary rocks of Pennsylvania, which are confined exclusively to this southeastern division of the state, spread over a very limited area, probably not exceeding one fifth of the surface of the district. They extend in two distinct and narrow belts from the Delaware river to the Maryland state line, occurring in the southeastern tract in one continuous range, but appearing in the northwestern one, only in insulated patches in the chain of hills called the South mountain.

The more southern of these belts commences at a spot in New Jersey about six miles northeast of Trenton, where the primary rocks emerge from beneath the overlapping red strata of the middle secondary series, commencing in a narrow point, they gradually expand in width as they range southwestward along the southern border of the state and the adjacent parts of Delaware and Maryland. The southeastern margin of these primary rocks crosses the Delaware river a little below the bridge at Trenton, and passes by Bristol, Philadelphia, Chester and Wilmington, keeping parallel with the general course of the river, separated from it by a narrow fringe of overlapping diluvial and alluvial deposites of rarely more than a single mile in width. The northern margin commencing at the same point in New Jersey, crosses the Delaware about a mile and a half above Trenton, and stretches in a somewhat undulating line south of west,

so as to meet the Schuylkill about two miles below Norristown and the Susquehanna at Turkey hill below Columbia. Between the Susquehanna and the Maryland state line, its course is rather more southwesterly.

The long wedge shaped tract here deliniated, has not as yet been traversed with a view to that minute and systematic examination which it demands. It offers for Geological exploration many useful and interesting materials, among which are belts of gneiss and sienitic trap rock for building, with a formation of crystaline marble in much request for the higher purposes of architecture, besides many exposures of serpentine, beds of whetstone and localities of valuable and curious minerals, such as the ores of iron, manganese and chrome. The investigation of the Geology of this belt of country and its mineral contents, will form a part of the business of the survey during the approaching season. The primary rocks of the South mountain show themselves principally in the part of the chain which lies between the Delaware and Schuylkill rivers. They are largely developed throughout all that portion of the same range of hills which crosses New Jersey and New York under the name of the Highlands, but they gradually disappear in going southwestward after we enter Pennsylvania, especially as we approach the Schuylkill.

Between the two above mentioned rivers, the South mountains contain both the primary rocks and the lowermost formations of our lower secondary or Appalachian series, or in other words the sandstone which I have designated in my last annual report as formation No. I, the limestone formation II, and a little of the slate formation III; west of the Schuylkill, there is an insulated tract of primary rocks occupying an area of about nine miles in length by two and a half in width, commencing at a point about seven miles west of Reading and ranging along the southernside of Millbough hill, through a small part of Berks and the adjacent corners of Lancaster and Lebanon.

There are a few other very limited patches of the primary rocks confined generally to the summits of the sandstone ridges through which they seem to have been protruded by the agency of those subtereanean forces of elevation, which have lifted up those hills and tilted their strata into the inclined attitudes in which we behold them. Some of these occur in the chain between Allentown and Reading. That part of the South mountain which lies between Adams and

Franklin counties, and which is a prolongation of the Blue ridge of Virginia, embraces a far larger proportion of primary rocks, but its Geology and Minerology have not yet been examined; the exploration of those counties in the district, which lie southwest of the Susquehanna, having been unavoidably defered until the coming season.

Iron ores in the primary rocks of the South mountain.

Crytaline magnetic iron ore accompanies the gneiss rocks of the South mountains in our State in several places, though the veins are much less frequent and extensive than in the same formation in New Jersey. At Durham on the Delaware it exists in considerable quantity, to all appearance in the form of regular veins of injection, but these mines have not been wrought for many years.

At Mount Pleasant, in Colebrookdale township, Berks county, the ore is extensively excavated. It would appear to lie in beds, or rather in regular veins, and to be in truth, the magnetic ore of igneous origin, in a rotten and decomposed condition.

Between the northern margin of the southern tract of primary rocks, and the Kittatinny valley, nearly the whole surface with the exception of limited patches of primary strata in the South mountains, comprehending most of the hills of that chain, and the wide plains spreading southwards, from them, consists of the two great formations at the bottom of our lower secondary series and the overlying red rocks of the middle secondary group.

SANDSTONE FORMATION NO. I.

The white and grey sandstone (formation I,) which is the lowermost of the two former, occurs abundantly in the South mountains from the neighborhood of Allentown to the Schuylkill at Reading. In Northampton and the eastern corner of Lehigh, the sandstone though occasionally met with on the flanks of the hills, is subordinate in importance to the gneiss and other primary rocks upon which it rests; but in Earl township, Berks county it forms most of the higher hills. Between the Schuylkill and Susquehanna rivers this rock is largely developed in several ridges; it forms the mass of Millbough hill near Womelsdorf reposing upon the gneiss rocks that lie to the south and sustaining in its turn the limestone strata of Kittatinny valley. The relative portions of these three formations are here well exposed; it entirely covers the flanks and the summit of the ridge called the Welsh mountain, in the eastern corner of Lancaster and the adjacent parts of Chester counties. This uplifted belt commences about three and a half miles east of Morgantown, and terminates a little south of New Holland, having a length of about fifteen miles. On the south it lies upon the gneiss, the line of junction between the two rocks following the foot of the ridge, while on the north it is covered by the limestone which overlaps it to the very base of the hill. West of Churchtown, in Lancaster county, the sandstone has been brought to the surface, through the overlying limestone strata, in a little insulated hill, about one mile in length and it forms another very similar low ridge of about the same dimensions near Neffsville, where its strata dip away in the opposite directions from the summit of the hill forming thus an anticlinal axis, as it is termed, along its centre. Again in the western part of Lancaster county, this sandstone has been protruded through the limestone in the form of a bold ridge of hills which crosses the Susquehanna between the towns of Columbia and Marietta. The most eastern exposure of the rock in this tract, is near the village of Hempfield, three and a half miles from Lancaster, from whence the northern border of the stratum extends northward for about a mile to the White Horse tavern, and thence sweeps westward and southwestward, following up the valley of Kauffman's run, from which it stretches nearly westward to the mouth of the Chickasalungo creek. Its southern edge passes the village

of Mount Pleasant whence it extends with but little undulation to the Susquehanna, which it crosses not far above the bridge at Columbia. A little below that town and also at Marietta the sandstone beds are seen alternating with the lower strata of the next superior rock, the limestone (formation II,) exhibiting a southern dip at the former place and a northern one at the latter. Some of these upper alternating beds of the sandstone, graduate into a material which is in some places nearly a pure slate; in the bold exposure of this formation on the Susquehanna, we behold abundant evidences of the change which this rock has undergone in its texture from the heating action of the veins of quartz which have been injected into it from below. Some of these veins of quartz bear a marked analogy to those which, in the southern states contain the gold, a resemblance which has excited hopes from time to time that this enticing metal might really be present in some quantity within our state. But a careful analysis of the most promising specimens not only from the locality on the Susquehanna, but from several others in York, Lancaster, Chester and Berks counties, has assured me that any dreams of riches from such source must prove wholly delusive, no appreciable quantity of the metal having been hitherto detected. The copper mine ridge consists throughout the chief part of its length of this sandstone formation, and some of the hills bordering the western part of the limestone valley of Chester county on the north, would appear to contain the same rock. But this belt of country near the southern primary range has not yet been minutely traced.

This lowermost stratum of our secondary series is occasionally the repository of very valuable collections of iron ore, one very extensive and rich deposit of which occurs upon it on Chesnut hill, about four miles from Columbia. It lies in a basin shaped depression in the rock, and is sometimes confusedly mixed with sand, clay, and steatitic matter, and sometimes lies surrounded by a less proportion of foreign matter in nearly horrizontal beds. Large bodies of similar ore, technically termed the brown argillaceous iron ore, are associated with this sandstone or appear at least to have been derived from it, in several places near the South mountain chain, especially along the southern side of Kittatinny valley, in Lehigh Northampton and Lebanon counties. A little iron ore has been found in it in the Welch mountain near the turnpike, but not in sufficient quantity to be valuable.

LIMESTONE FORMATION NO. II.

Resting upon the sandstone just described, the next formation in the ascending order is the valuable blue limestone stratum which occupies nearly one half of the entire area of Lancaster county. This is the same rock with that which was described in my last annual report, as extending along the southern side of the Kittatinny valley, throughout its whole length, and which is there designated as formation II, in our Appalachian system of strata. It covers a large and important tract in the district southeast of the Kittatinny valley, spreading over the broad and fertile plain which extends in an east and west direction through the central townships of Lancaster and York counties. The eastern limit of this great expanse of limestone is about three miles east of Morgantown in the southern corner of Berks county. Its southeastern margin extends from thence along the northern base of the Welch mountain, which it follows to its western end near New Holland in contact with its white sandstone. There the limestone doubles round the end of the ridge and spreads eastward through the southern half of Salisbury township into Chester county. From Chester county, the southern limit of this rock follows, first the northern base of the Mine hill as far as Strasburg township, after which it courses along the foot of a chain of low hills in the same westward prolongation to the Conestoga creek; it then descends along the valley of this stream as far as the northeastern foot of Turkey hill, around the various spurs of which it winds until it reaches the Susquehanna river at the mouth of Wister's run. Throughout this course the limestone lies in contact either with the sandstone (formation I,) or with the gneiss or talc slate rocks of the primary class. The northern margin of the limestone starting at the same point near Morgantown, ranges westward across Lancaster county in a somewhat undulating line to the Susquehanna which it crosses immediately above the village of Bainbridge. Lying to the north of this large expanse of limestone and separated from it by a long tongue as it were, of the red rocks of the middle secondary series, are two other valleys of the limestone, the eastern one contains the waters of the Cocalico creek, and the western one the Moravian towns of Litiz and Manheim. The limestone along its whole northern limit, between Morgantown and Bainbridge disappears beneath the

overlapping strata of red sandstone of the middle secondary series, the beds of which may be seen resting upon it in an *unconformable* position having generally a dip toward the north at an angle of from fifteen to twenty-five degrees. There is evidence that these newer or middle secondary rocks once spread themselves southward over the limestone much more extensively than at present, the destructive agency of a heavy current of waters having removed a large tract of the uppermost formation. To the same action we may refer the peculiar bench or terrace which the overlying red sandstone uniformly presents along its margin rising from thirty to forty feet above the plain occupied by the limestone. The removal of the upper rocks at a point about four miles west of Manheim has laid bare a small and narrow patch of limestone upon Chickasalungo creek not much exceeding half a mile in length.

This valuable formation likewise shews itself in a few confined valleys subordinate to the South mountains, in the neighborhood of the Delaware and Lehigh rivers, one of these tracts ascends the valley of Durham creek from its mouth as far as Springtown, the calcarious rocks shewing themselves even to the west of Hellerstown road; another belt of it pursues the valley of Saucon creek to its very head almost two miles northeast of Shimersville. A narrow strip of the same rock is seen along the Little Saucon creek for about three miles above its mouth. Further towards the southwest the limestone is less abundant, being seen only in small and detached exposures. It occurs thus in several localities in Upper Milford township, Lehigh county, and in Henford township, Berks county, as far as the point where the chain of hills divides. The valley here formed, constitutes parts of Oley township, which consists of the limestone in the eastern and southern part and of the overlying slate, (formation III,) in the northern and western part. The limestone also occurs at intervals along the northern margin of the red sandstone. In some of these exposures, as in Douglass township, the limestone is seen in immediate contact with the overlying red sandstone, and in several neighborhoods, as for example, at the south base of Neversink hill below Reading, the very singular, coarse, variegated conglomerate which in this part of the state forms the uppermost bed of the middle secondary group may be seen dipping directly against the highly inclined strata of the limestone,

MIDDLE SECONDARY RED SANDSTONE FORMATION.

We come now to the red sandstone formation which stretches through the central and northern portions of our southeastern district in a long and irregular tract from New Jersey to Maryland. As a group of rocks this is one of the most remarkably uniform in respect to its materials and appearance in our country. It consists of dark reddish brown sandstones, almost invariably argillaceous of soft crumbly brown shales and coarse conglomerates, frequently of very heterogeneous composition. The prevailing, we might say the almost invariable direction of the dip of these strata is towards the north at angles varying from fifteen to twenty-five degrees. The lower beds or those which shew themselves along the southern edge of the tract consists most frequently of rather coarse sandstones alternating with red shales, the sandstones being formed of somewhat augular fragments of quartz, felspar and other ingredients of the neighboring primary rocks, cemmented by a paste of brown argillaceous matter. The central parts of the formation consist more exclusively of brown shales and brown argillaceous sandstone while the uppermost beds occurring along the northern margin of the formation, have frequently the character of coarse conglomerate, made up of pebbles derived from a very great variety of rocks, chiefly those which occur at the base or on the sides of the adjacent hills of the South mountain chain, where a large proportion of the pebbles are of limestone and the cementing red earth which unites them contains an adequate quantity of the same materials, the rock possesses the character of a marble being susceptible of a good polish and resembling certain highly variegated breccias.

Of this character are the beds of this rock near the Potomac river, which furnished the columns in the house of representatives and the senate chamber of the capitol at Washington. The same rock occurs in the vicinity of Reading, and at many other places along the same line crossing our state, and in every respect seems equally well fitted for the purposes to which the so called Potomac marble has been applied. The hardness of some of the pebbles and the consequent difficulty of dressing and polishing this rock will account for its not having been hitherto wrought as an ornamental marble in our state, but it is possible that by a judicious application of machinery it might be profitably worked.

Though this conglomerate constitutes the uppermost member of

the red sandstone group in various places, both in New Jersey and Pennsylvania; there are other neighborhoods, where, for example, near Bainbridge on the Susquehanna, it would seem rather to occupy a position at the base of the series. All these rock of the middle secondary date of which the argillaceous red and brown sandstone is the predominant and characteristic variety appear from numerous geological indications to have been produced at a period subsequent to the elevation of the lower secondary strata including the coal deposits. They seem to have originated in a long narrow trough or bay which had its source at least as far south as the central latitudes of Virginia, and which probably opened into the ocean somewhere near the present positions of the Raritan and New York bays. Their materials give evidence of having been swept into this estuary or great river from the south and southeast, and hence the almost universal dip or inclination of the beds towards the northwest, a feature clearly not produced by any uplifting agency, but assumed originally at the time of their deposition in consequence of the direction or set of the currents, which laid them down layer after layer. With the exception of one or two fossil fishes found in this formation in New Jersey, I am not aware that any animal organic remains have been hitherto met with in any part of the stratum, and hence it becomes difficult to assign its precise place in the general series of Geological formations. Relics of vegetation are however occasionally found under the form, especially of highly compact and bituminous *lignite*, the transverse section of which bears no remote resemblance to some kinds of cannel coal, while the longitudinal section exhibits very distinctly the fibrous structure of the wood whence it has been formed. This lignite occurring sometimes in seams of two or three inches thickness amid dark shales, has been a fertile source of delusion; some persons having been induced by the hope of finding valuable coal mines to expend both time and substance in the search. All the Geological facts procured during the survey of this formation discountenance the notion that it contains any coal. It seems to have originated at too late an epoch for the production of coal, the conditions under which its deposites were swept together being apparently inimical to the accumulation of a sufficient quantity of vegetable matter; the detached fragments of plants which we meet with in the form of lignite, having evidently been loosely drifted into these sediments from the land.

The general limits of the red sandstone formation as far as regards the region between the Delaware and Susquehanna rivers, are as follows: Its southern margin crossing the river about a mile and a half above the town of Trenton, runs nearly westward to the Schuylkill, passing about two miles south of Norristown, it there extends by Valley Forge and Kimberton to French creek, the course of which it follows nearly to the county line of Chester. It passes about half a mile to the north of Morgantown, Churchtown and Hinkletown, and goes through Millport to Buchanan's run, when it suddenly folds back and runs towards the northeast, through Ephrata to Reamstown.— From the last point it sweeps in a regular curve, first towards the northwest and afterwards the southwest, crossing the turnpike at Middle creek. Reaching Hammer creek it descends along the course of this stream to Erb's mill, where it turns again westward passing about a mile to the north of Litiz, and reaches in the same course Manheim. Here it goes once more towards the east which direction it pursues as far as Buchanan's run, where, however it again turns westward, continuing in that course uninterruptedly to Springfield, at which place it makes another short flexure but soon resumes its western range, passing one mile and a half south of Elizabethtown, and thence nearly in a straight line southwestward to Bainbridge on the Susquehanna. From the Delaware river at Trenton to the Warwick mine, near the head waters of French creek, the red sandstone stratum overlaps the gneiss and other rocks of the primary class.— From the latter point it ranges in contact with the white sandstone of the Welch mountain, but on entering Berks county and in its course across the whole length of Lancaster county, its southern margin is every where in junction with the limestone. The northern border of this middle secondary formation, beginning at the Delaware near Durham, if traced westward across our district will be found to pass about one mile south of Springtown and one mile north of Cooperstown to the Hosacock creek, where the road crosses it in Upper Milford township. It then runs a little to the south of Mount Pleasant iron mines, passes Boyerstown, crosses the Perkiomen one mile south of the Black Bear tavern, and meets the Schuylkill about two miles south of the town of Reading. The Potomac marble or calcareous conglomerate occupies several long narrow tracts along the line just traced; one a little below Springtown, another on the Manatawney creek, and a third on the Limekiln creek. It has already been alluded to as occurring on the Schuylkill below Reading. From this latter

point, the northern edge of the sandstone stratum extends with a slight undulation in a nearly western direction to the southwestern end of Millbough hill, overlapping first the limestone of the Kittatinny valley, then primary rocks, and finally the white sandstone of the hill. From Millbough hill its range is a little south of west, through Sheafferstown, past the Cornwall iron works and thence along the turnpike to Campblestown, from which it takes a nearly straight course to Highspire on the Susquehanna. Between Millbough hill and the Susquehanna, the red sandstone formation lies every where in contact with the limestone of the Kittatinny valley.

TRAP ROCKS.

The red standstone formation embraces numerous ridges and dykes of trap rock, indeed nearly all of this rock which is contained in our state is confined to the area occupied by that stratum. It occurs principally in the northeastern half of the tract. The trappean matter brought to the surface in a state of fusion, through the dislocated red sandstone beds, gives frequent evidence of its having had a heat which has entirely changed the character of the shales and sandstones, which have sometimes the aspect and texture of an over-baked brick or tile. The Conewago hills consist of the trap rock in several varieties, both fine grained and coarsely chrystalline.

IRON ORE IN THE RED SANDSTONE FORMATIONS.

There are several places in the red sandstone tract, where iron ore exists in greater or less abundance. The three principal localities between the Susquehanna and Schuylkill, are the Cornwall mine in Lebanon county, Jones' mine about three miles from Morgantown in Berks county, and the Warwick mine six miles northeast of the same place on French creek in Chester county, The Cornwall mine is extensive and yields ore of very considerable richness, which, however, contains a small proportion of copper. The mine near Morgantown, though formerly wrought to some extent, is now of comparatively little value. The ore is mixed with carbonate and silicate of copper, the excavation having originally been undertaken as a copper mine. In the Warwick mine the ore is apparently of good quality but hard. A mixture of this and the previously mentioned ore is said to yield a very good metal. All the three iron mines here enumerated occur in the red sandstone, but in the immediate vicinity of dykes of trap rock.

The ore is manifestly of igneous origin, much of it being chrystalline and magnetic, and appears like the trap to have been injected into the sandstone in a melted condition.

This proximity of the ore to that rock, suggests the same practical rule for its discovery which applies to the copper ores throughout our state and New Jersey, namely: that we should seek for its external indications either immediately along the base of the trap ridges or within a short distance from them. Similar iron ore occurs in the district between the Schuylkill and Delaware rivers, in the red sandstone. The principal mine in this region is Fegeley's at Boyerstown, not at present in operation, in the vicinity of which there is another mine (Rhodder's) in which the ore is magnetic. Numerous details regarding the ores and other useful materials connected with the red sandstone tract of the state, are reserved unavoidably for the more ample pages of the final report.

The opportunity will then be embraced for introducing many particulars respecting all the various substances of any economical value which appertain to the several formations already described, among which are all the iron ores of the South mountain, whether associated with the gneiss rock, the sandstone formation I, or the limstone formation II, also useful building materials, including ornamental marbles, the whetstones of Hereford township in Berks county, and clays for brick making, and whatsoever else may be deemed of practical importance.

SECTION II.

GENERAL SKETCH OF THE OPERATIONS IN THE SECOND OR NORTHEASTERN APPALACHIAN DISTRICT.

The operations of the survey in the northeastern half of the Appalachian region of the state, have been principally restricted during the past season to our middle and southern anthracite basins; the detailed exploration of which was systematically entered upon in the previous year. Aided in this part of the survey by two of my assistants, who have taken an active part in the examination since its commencement, I have been enabled to carry on without interruption or change of plan, the investigation of this highly important and intricate region, giving to the work as it advances, such increase of accuracy in its details, as reiterated observations can alone secure in a country possessing its peculiar and complex structure.

For a more full account of the object and the nature of the measurements performed in the course of this investigation, among these several coal basins and their individual seams and strata, I must refer the reader to my second annual report on the survey. I may however state, that our recent researches in this region have been conducted with a view to delineate as accurately as possible, the boundaries of the several coal basins, to ascertain the relative position, and trace the actual range of each of their important beds of coal, and to discover the existence and trace the direction of all important axes of elevation, and all great dislocations by whose agency the strata are displaced from their regular course, and thereby the hopes and labours of the miner too often frustrated.

In order to accomplish these objects, several distinct species of investigation have been resorted to as necessary.

First. The topography of the region has been critically examined, and the essential dependence which exists between even its lesser features and the Geological structure at each place, carefully studied, as necessary to the construction of a *Geological map* of the whole on a large scale, shewing the limits of each basin, the position and range of its principal beds, and of the more influential lines of disturbance affecting the strata.

Secondly. The *superficial evidences*, embracing an examination of the external characters and dip of the strata have been systematically collected with a view to shew the presence or absence of coal measures, and to identify and trace the several beds.

Thirdly. A series of parallel lines at right angles to the course of the strata, have been *measured* and *levelled*, in order to ascertain more strictly the boundaries of each basin, and the true situation as far as possible of each coal seam, and to detect any increase or diminution in the breadth and probable depth of the former or in the mutual distances of the latter, and to impart additional precision to the sectional drawings, which are to elucidate these points, by procuring correct outlines of the surface.

When it is understood by what invariable relations the Geographical and Geological structure of our Appalachian region are connected together, the necessity for this first preparatory operation, *the construction of a map*, on which to lay down our results, will become obvious. Of those at present, in use, the best are well known to be defective, and for Geological researches, where slight variations in the

course and shape of the mountain ridges and axes of elevation are found to correspond with important changes in the position and direction of the strata, they may be considered as wholly useless.

Abstaining from all minute and local details, referring to particular mines or individual coal beds as not suited to an annual report, from which the indispensable illustrations of maps and sectional drawings which will accompany my final report are necessarily excluded, I shall confine my remarks on the present occasion, to a description of the position and range of the several leading anticlinial axes of our great southern and middle coal fields, or what is the same thing, to a rapid specification of the approximate boundaries of the coal measures, in the numerous lesser basins or synclinal troughs into which those axes subdivide the whole anthracite region. The information imparted in the few following pages will tend, I trust, materially to aid the examinations of those who are aiming to determine the important question of the existence or absence of coal upon their lands, and if closely attended to, may essentially assist the explorer in ascertaining the true limits of the coal, especially in some of the less known basins. If it should deter even a few from the wasteful expenditures, and many ineffectual enterprises for establishing mines in neighborhoods where the position of those axes, and the appearance at the surface of the lower strata, prove even without assistance from other Geologibal evidence, that no coal measures can exist, I shall deem it of more general utility, than anything in the shape of local details that I could offer in the narrow limits of the present brief report.

In the attainment of this object, combining also careful observations of the soil, the dip and character of the rocks, the position and number of the coal beds and deposites of iron ore, the greater portion of the past season has been occupied. The other portion of our time was employed in the collection of specimens, the tracing of coal beds, and in more minute observations on the disturbances of the strata, made both on the surface and under ground in numerous tours of inspection, for this purpose, through the mines. In the Beaver Meadow district, two parallel and long lines of levelling have been completed between seven and eight miles apart. One of these measurements was commenced upon the Spring mountain, opposite the town of Beaver Meadow, and carried in a direction north, 20 degrees west, or nearly at right angles to the range of the strata, and made

to terminate on Buck ridge six and a half miles distant. The other was commenced upon Buck ridge opposite the Sugarloaf mountain, and directed south 20 degrees east, to its termination upon the Spring mountain, near its western extremity.

The coal deposites of the anthracite region admit of a natural and scientific division, into four distint groups. First in extent, though not at present in importance, we have the great northern basin, extending from a few miles north of Carbondale on the Lackawannock creek to the Knob mountain, where both boundaries of the basin near their southwestern junction are broken through by a notch, giving passage to the river Susquehanna. Separated from this basin by the great anticlinal axes of the Wapwallopen hills, by which the rocks of our formations VIII and IX are brought in succession to the surface, we find the eastern or middle anthracite coal fields composed of eight narrow basins, lying contiguous to each other and containing the lower coal beds of the series, one of which is of great size and importance.

Cut off from these last by the deep red shale valleys of the little Schuylkill, Catawissa, and other streams, but situated nearly in the same range, we have the coal fields of the Mahanoy and Shamokin, composing our next natural group of basins. And lastly south of all these and separated only by the high anticlinal axes of Broad mountain, lie the Broad mountain, Mine hill, and Pottsville coal basins, the last extending eastwardly to Mauch Chunk and westwardly to the neighborhood of Pinegrove, when it divides into two branches, the northern one under the name of Wiconisco mountain extending westwardly several miles beyond the county line of Dauphin and Schuylkill, to Lykens' valley; and the other embraced between the Stony mountain, and a continuation of the Sharp mountain, reaching nearly to the Susquehanna river. From Geological evidences too numerous and striking to be questioned, we infer that all the coal deposites of our anthracite region with their associated rocks, owe their present more or less inclined posture and their limits, to the influence of two grand causes, namely: subterranean elevation and the superficial denuding action of a deluge. Keeping in view the joint operation of these forces, we are enabled to explain as their natural and necessary consequences all those singular positions and complicated disturbances of the coal measures which are so apt to deceive the calculations of the miner, and to elude the researches of those who have adopted their

ideas of the structure of all coal basins from the simpler forms of the celebrated European coal fields, or the descriptions of elementary books.

As the natural result of the above mentioned causes, we find our anthracite basins connected together in the groups above described. The great stratum of conglomerate rock, formation XII, which is found so remarkably developed in the Sharp and Broad mountains, may be seen underlying every coal field in the region, and indeed points enough of connexion could be traced, which would show the absolute identity of the conglomerate of the Beaver Meadow and Hazleton region, with that of the Mahanoy, and of this again, with that of the Shamokin and Broad mountain troughs, and of the latter with that of Mine hill and Pottsville basins. Between the conglomerate strata of M'Cauley's mountain and Buck's mountain, and between those of the Buck's mountain and Wyoming mountain, there is a wide interval, but we have ample Geological evidence to prove, that by the elevation of the lower strata which are here exposed, the conglomerate and its superincumbent coal measures being brought within the influence of denuding currents, have been swept entirely away, leaving no space between, to shew the original continuity of the deposites of the now insulated basins. Commencing with our eastern or middle district we find seven distinct synclinial basins of the coal measures grouped in close connexion. These may be compared to a like number of long and narrow troughs, lying in contact and parallel with each other. Their range is south sixty-five degrees or seventy degrees east, though particular portions affected by faults or by greater disturbances, present considerable deviations from that direction.—These are either separated from each other in every case, by parallel anticlinal ridges of conglomerate rock, or when that has been carried away from a deeper denudation than usual, they are then divided by narrow vallies of the red shale of our eleventh formation. This latter, is the common structure at the eastern and western extremities of the coal fields, where we find the coal basins terminating abruptly in a prow shaped form, in those conspicuous mountain spurs or high promontories which stretch eastward and westward from the elevated level of the coal field, into the lower red shale vallies of the Lehigh and Cattawissa. Between the two great axes of the Nesquehoning mountain, and the Wapwallopen hills, in both of which, the sandstones of our formation IX, are brought into view, six lesser anticlinial axes

or undulations of the dip are discoverable. The most northerly of these lines of elevation in the strata, crosses the river Lehigh, in the neighborhood of Whitehaven, and passing about west ten degress south, terminates in the great bend of the Little mountain, near Catawissa. Upon the north side of this axis which passes through the central table land which unites the Green mountain with the Buck's ridge, we find the north dipping conglomerates of a small coal basin occupying the summit of Green or Hell Kitchen mountain.—In the range of the above basin, but separated by an interval of six or seven miles, we have the Sugarloaf mountain, lying upon the north dipping beds of this same axis, but containing no coal measures. This latter eminence consists of a mass of the red shale rocks in a nearly level position, capped with a narrow plateau of conglomerate rock, about one hundred feet in thickness. Continuing our range still further westward, we find the small coal fields of M'Cauley's mountain, crowning an isolate ridge of conglomerate, which has been at one time evidently continuous with the conglomerate stratum of the Sugarloaf and of the Green mountain. On the south dips of the above mentioned axes lies the conglomerate of Bucks mountain. Again, at the junction of the two branches of Black creek, we find evidence of another additional elevation which may be traced eastward through the long summit of Black creek ridge until it is lost in the neighborhood of the Lehigh, and westward through the Racoon valley, between the south Buck's mountain, and the Little Sugarloaf as far as the base of Little mountain. Between these two axes lies the coal basin of Buck's mountain. Our third axes is that of the Council ridge, situated south of the last line, about one and a half miles. This, in its turn, seems to disappear eastward in the vale of Sandy creek, and westward in the red shale valley at the foot of Little mountain. Between this and the former, lies the coal basin of Black creek, a long narrow trough of conglomerate, with a rather shallow deposite of coal measures, commencing at the head waters of Black creek, and terminating in the Little Sugarloaf mountain, which lies between the two branches of the Tomhickon creek.

The fourth in order, and ranging at a like distance south from the last three, is an axis observable near the junction of Hazle creek, and Dreck creek, which we shall call the Dreck creek axis. This is continued eastward through the centre of Pissmire ridge to the Lehigh, where it terminates. We may trace its prolongation west-

ward to the very extremity of Green mountain, and thence through the Catawissa valley, in which it seems to expire. Between the Council ridge axis, and that last described, we find the valuable basin of the Hazleton valley, extending eastward to the extremity of Pissmire hill, and westward to the end of Green mountain.

Our fifth axis is the great one in the southern ridge of Pissmire hill, passing near the town of Beaver Meadow. This line of disturbance traverses the valley of Red Shale, called the Indian survey between Spring mountain and the northeastern prong or spur of Pissmire ridge, while westward after leaving the coal field, it keeps along the south foot of Green mountain, until lost in the Catawissa valley. This axes is the southern limit of the Dreck creek basin, a coal deposite, which in depth and breadth is much inferior to that of Hazleton, to which it is precisely similar in the topography towards its east and west prolongations. In the red shale valley of Quakake creek, we find another axis which flattens out and disappears near the crossing of the Beaver Meadow rail-road, through this valley. It is this disturbance which causes the northern dip of the conglomerate in the Spring mountain. Upon this stratum, and upon the southern dipping conglomerate of the Pissmire ridge, lie the coal measures of the Beaver Meadow basin. This is perhaps the largest and most valuable coal field in the *group*, but is at the same time the most disturbed by *dislocations* and *rolls* of the strata. Commencing at the town of Beaver Meadow, and proceeding westward, we may trace the rise and declension of several axes or wrinkles, caused as it were by the upheaving and by the consequent inward pressure of the two bounding masses of the conglomerate. Such is an outline of the general structure of the eastern middle group.

Our western middle group of basins, including the coal fields of Mahanoy and Shamokin, presents some features of a different character. Owing to their position between the eastern terminations of the two great axes or lines of elevation, those of the Roaring creek, and Mahantango valleys, we find the anticlinal disturbances in this group of considerable size and consequence, dividing the extremities of the coal basins and thus causing them to branch off into several small spurs of a synclinial structure, which however communicate uninterruptedly with the main vallies or coal basins.

Commencing at the western termination of the great Shamokin

coal field where the north and south dipping ranges of the conglomerate unite together, in a high knob between eight and nine miles west of Shamokin gap, we can trace as we go east, a regular basin of coal measures of uncommon width and depth, disturbed only by a single central axis of elevation, which does not bring the lower rocks to the surface. This axis will be found to assume its maximum elevation and importance, uptilting the strata near the Shamokin coal mines, when it soon begins to fall away towards its eastern prolongation, disappearing after a distance of five or six miles. Two or three other similar disturbances but of less note, begin near Shamokin gap and proceed eastward in a parallel direction, but die away in short distances and are succeeded by others of the same nature. About the crossing of the Sunbury turnpike the valley presents an appearance of remarkable regularity in its topography, if we confine our views to its western portion, but looking towards the east we perceive the rising of two prominent ridges of nearly equal elevation with those enclosing the whole coal field, and which prove upon examination, to contain the terminations of two great anticlinal axes or lines of elevation dividing the coal field into three branches. The northern and middle of these subordinate basins terminate abruptly in short and high hills. The southern, however, continues with a longer reach along the southern side of the north ridge of the Mahanoy, and thence after being completely divided by a breach or gap runs out in the Head mountain, which is a dividing ridge of the Quakake valley, lying almost in immediate contact with the Spring mountain. In the proximity of these two latter mountains and their anticlinal axes, we behold the natural link connecting our eastern and western sets of coal basins. Parallel with this last axis and in the same long spur of the Mahanoy mountain, there is another diminutive trough of the coal measures, which is in like manner, an extended arm of the great coal basin of the Mahanoy. The central axis of Head mountain, dividing these two lesser basins is a low ridge of conglomerate rocks, which, if traced westward will be found to be identical with the great anticlinal axis of Locust ridge which separates the two main basins of Shamokin and Mahanoy. The great basin of the Mahanoy valley terminates westward in a knob of the main mountain, forming the south boundary of the Mahanoy basin, at a point about two miles south of the Shamokin mines. This knob faces westward upon the Red Shale valley, which lies between the north Mahantango ridge or Line mountain and the south boundary mountain of the Shamokin basin.

From this point eastward, the valley gradually increases in breadth and depth as far as the western commencement of Bear ridge, when it reaches its greatest expansion. The great anticlinal axis of the Bear ridge, rising in the centre of this coal basin, divides it into two large branches. The northern one of these, or the basin of the Shenandoah valley, if traced eastward will be found identical with the southern coal trough of Head mountain above described. The other lying to the south of Bear ridge, after continuing eastward about five miles is there subdivided by another similar axis but of less elevation. The two troughs thus formed contracting and rising, extend eastwardly into two long spurs or fingers, the more northerly of which terminating in a high knob facing the south branch of the Quakake valley, feeds the sources of the Mahanoy creek. The southern of these synclinal troughs on the other hand, heads eastward in a knob called the Hossasock mountain, reaching out from Mahanoy mountain into the Locust valley. A third, but smaller basin also takes its rise in this knob of the Mahanoy mountain, and terminates near the summit of the steep plane on the Danville and Pottsville rail road. South again of this last shallow trough, is another, taking its rise in a knob of Broad mountain, which faces the Nesquehoning valley towards the east, being a coal basin of little depth or consequence at its origin, but which may readily be traced and will be found to be identical with the central basin of the Broad mountain. The basin which we mentioned as terminating at the head of the steep Mahanoy plane, would, if continued, pass into a narrow coal trough lying along the northern edge of Broad mountain, and ending in a shoulder or knob on its western escapement opposite the junction of the Great and Little Mahanoy creeks. The central basin of Broad mountain, (in which is Spohn's tavern on the turnpike,) terminates westwardly in a spur jutting forward from Broad mountain towards Lykens' valley. This spur contains also the heading of a second very shallow and less obvious basin lying immediately to the south of the former, but which is of small consequence, as it seems to contain not even a remnant of the coal measures. This, and a third still narrower one may be seen at the passage of the Centre turnpike over Broad mountain. It is doubtful if either of these three last mentioned mountain troughs contains any considerable quantity of coal measures. Beside the spur of Broad mountain which we have just mentioned as jutting westward, two others are conspicuous in the same neighborhood facing upon the Ly-

kens' valley. These two prominences of the plateau of Broad mountain, the most southerly of which is the longest, extending itself several miles towards the west, contain *two branches of the Mine hill coal basin.* The central valley of red shale dividing these two knobs contains an anticlinal axis which may be seen terminating in the Mine hill valley, about a mile west of Coal Castle. The axis next south of this, which may also be traced for a great distance along the valley of Pine creek, and upon which this creek had its source, is *the true axis of the Mine hill*, dividing the Pottsville from the Mine hill basin.—This in its turn, terminates in the neighborhood of Tuscarora, where this basin of Mine hill coalesces with the great southern one, or that of Pottsville and Mauch Chunk. Such is a general outline of the districts which have been embraced by our researches and surveyed in considerable detail during the past season.

The great southern coal valley of Pottsville, has also been in many of its parts minutely explored. In the course of this investigation, the situation of numerous important points was referred to a map, all disturbances of the strata that came under notice, were traced as far as possible or to their terminations, and their extent and direction ascertained, with a view to the discovery of the *general laws*, regulating the disturbances of the strata in this intricate but valuable region.

Particular observations have been made, with a view to form an opinion as to the capacity of the Bear ridge district, as a productive coal field. The present position of the Bear ridge tunnel, seems to adapt it very perfectly for an opening and outlet to the main body of the coal field north of it. The Bear ridge, is, as we have already indicated an anticlinal axes, coming in from the Quakake or Locus. valley and dying out in the centre of the coal basin near Girardsville. This axis from its origin at Girardville, increases in elevation eastward, bringing up first the lower coal measures to the surface, with their coal beds as at the tunnel, and afterwards in succession, all the conglomerates and other rocks to the underlying red shale which appear first near Brouse's tavern, on the Cattawissa road. At the tunnel we have two or three coal beds rising from the vale of Mahanoy creek at an angle of from sixty to fifty degrees, which after saddling the ridge, dip rapidly downward to the north at an angle, increasing from ten to thirty degrees as we follow them more deeply. But in addition to those beds which pass over the ridge without fairly cropping out upon the surface, we have upon the northern side and super-imposed

upon them six or seven others, many of which must be of considerable thickness. The vale of Shenandoah, into which these north dipping coal beds descend, is a long narrow valley about one-third of a mile in breadth, reaching eastward to the sources of Shenandoah creek, and westward to a little beyond Girardville. The dip of the coal measures upon its northern side which is formed by the south flank of Locust ridge, is south. This, with the northern dip of the strata of the Bear ridge forms a regular synclinal trough whose eastern prolongation terminates only in the end of the Head mountain, of whose southern basin it is the true continuation. The denudation in this basin opposite Bear ridge has been comparatively small, a great depth of coal measures still remaining on both sides of the valley. So far as we may judge from external indications, these are remarkably regular and free from anticlinal or other disturbances. Considering these circumstances, we may readily conceive, that great advantages would follow the completion of the present partially finished tunnel through the Bear ridge. Not only would all the coal beds of the south and north sides of Bear ridge be made accessible to the miner, with an uninterrupted range to the eastward for many miles, but the tunnel being driven at a level of only sixty feet above the level of Shenondoah creek, might form an outlet for all coal mines east of that point on either side of the basin.

A set of Geological specimens has been collected illustrating all the beds of the conglomerate, and the coal measures of the Bear ridge and Mahanoy mountain. A large collection of fossil impressions of the coal plants has also been gathered from the rocks of the tunnel.

In the great southern basin, the operations of the survey during the latter part of the season have been directed to the elucidation of a subject of the greatest interest to the miner and the land owner in this region, I mean the disturbances of the coal beds and their included strata. To this end, the dip, thickness, and peculiarities of stratification of the coal beds have been obtained at the principal openings, their distances measured, their positions as far as practicable, traced upon a map of an adequately large scale, and attempts made wherever any hope of success appeared, to identify the beds at distant openings. All the anticlinal disturbances which time permitted us to trace, have also been carefully noted, and a number of remarkable faults observed, with a view to ascertain if possible, some

rule respecting their directions and influence upon the strata. From the large number of specimens taken during the last season from this district, it was deemed unnecessary to collect many of these in the southern basin excepting in a few instances.

A few of the conclusions arrived at, will serve to explain the nature and results of these investigations.

From the comparison of a great multitude of facts we are led to conclude that the southern coal basin throughout its whole length, is traversed longitudinally by several great *lines of disturbance* in the range of which may be found a greater number of faults, downthrows and longitudinal displacements of the strata and the coal beds, than can be discovered in the belts intervening between them. These lines of disturbance are indicated either by regular anticlinal elevations, which commence and terminate in distances varying in length from a few hundred feet to several miles, or by simple but sudden changes of the dip, (the rocks not forming a complete axis) or by crushed coal seams where no disturbance in the adjoining rock is visible. Of the first kind of irregularity, the Bear ridge east of Port Carbon and the axis of Peach mountain are well known instances; the second kind may be observed in the rather sudden change of inclination at the foot of Mine hill, from steep south dips of sixty, to gentler ones of ten or even five degrees south. For the latter, we may refer for illustration to the beds of the barren tract and the faulty portions of the Gate vein. Passing over the eastern portion of the basin through which, indeed, anticlinal disturbances are well known to pass, let us commence with the Sharp mountain at Middleport, near Pottsville.

From this eastward to a point south of the above mentioned village, the rocks of Sharp mountain being overtilted or inverted towards the north, have a steep southern dip; at this point, however, we find them changing to a perpendicular position, and from this rapidly to a north dip, then to a west, and again to a south one, the last being gentle and not exceeding thirty degrees. In these changes the southern or outward base of the mountain sweeps sharply round in the form of a bold promontary, and the returning or northern side of the spur contains the last mentioned southern dips.

Again repeated, but with less steep inclinations of the strata, we have the same series of changes, after which deviations, the mountain assumes a course of forty-four degrees east of north for some miles, and then continues in its ordinary range. It is easy to con-

ceive without entering into theoretical considerations, that these disturbances have been caused by the intrusion of two anticlinal axes which have their origin in the Red Shale valley, between the Second and Sharp mountain. These seem soon to flatten out and disappear within a short distance to the west in the coal basin, but in the several anticlinal elevations and the numerous faults of the Bear ridge, we have evidence of a disrupting effect prolonged much further in that direction. We lose sight of this line of disturbance near Port Carbon.

Passing towards the western extremity of the basin, we perceive two great anticlinal axes entering it from the west from Williams' valley, the southern and lesser of which is probably prolonged eastward, through the range of the barren tract noted for the crushed character of its veins of coal, while the other, a far more important axis passes along the central part of the basin, producing as far as evidence goes, the Minersville disturbances, (which may be seen in certain coal beds worked by Spencer & Co.) and in others, less known, some miles west of these, and prolonging itself further eastward into the great Peach mountain axis itself.

Our next conspicuous range of disturbance in the coal measures, lies along the foot of the Mine hill, but is of a less striking nature than the former. By its influence, the flat beds of the Mine hill seem to have been brought to their present posture. The crushes and rolls in Neighley's, and some other of the Mine hill workings, present other examples of this line of dislocation.

From the above and other analagous details, we conclude that the number of coal beds at present worked in this district has been somewhat over rated, for, in no instance can a north dipping bed be found, to which there are not two related south dipping portions. Thus the Lewis and Spohn veins opened upon the workings of the North America company's lands, must be considered as identical, having a north dipping or perpendicular bed, and none other between them.—In consequence of this fact, all attempts to trace the Lewis and Spohn veins as separate beds, either eastward or westward beyond where they are already known, will probably prove abortive. One vein alone can be hoped for, unless the dislocation is prolonged to a greater distance than present evidence indicates.

SECTION III.

A GENERAL SKETCH OF THE OPERATIONS OF THE SURVEY, IN THE THIRD OR SOUTHWESTERN APPALACHIAN DISTRICT.

In conducting the examination of the third district of the state, or that which is occupied by the half of the Appalachian chain, included between the Susquehanna river and the southern boundary of the state, the exploration was begun at the northeastern extremity of the region in Union and Lycoming counties, and pursued regularly towards the southwest, following the course of the formations. The season was commenced with the survey of that portion of Union county, known as Buffalo valley, and as it was deemed judicious to confine our attention for the season, to a tract of moderate breadth, the lower part of Union county, situated to the south of New Berlin and Jack's mountain, was reserved for an ensuing year.

The strata underlying the broad surface of Buffalo valley belong, with the exception of one or two small patches of formation No. VIII, near Lewisburg, to formations V and VI, the general composition and prevailing mineral, contents of which will be found described in the last annual report.

As formation V of our series, is the depository of the valuable and interesting *fossiliferous* iron ore found in such considerable abundance in the eastern half of Montour's ridge, in Columbia county, it was deemed of consequence to the interests of Union county, to examine the red and variegated shales and sandstones of which this formation consists, with all the minuteness compatible with the rather obscure developements of the strata in most parts of Buffalo valley. A remarkably near approach to identity, being discoverable between the several members of this great fifth formation as seen in Buffalo valley and in Montour's ridge, it was not difficult to recognize from the examinations and measurements undertaken the previous year in the latter neighborhood, the precise layers which should contain the fossiliferous iron ore supposing it to exist at all in Buffalo valley.—This valley encompassed on the north and west, by the terminating spurs of the broad belt of mountain ridges that crosses Centre and

Mifflin counties from the southwest, the lines of elevation of these hills prolonged beyond their extremities, are traceable as far as the Susquehanna river, uptilting the strata in Buffalo valley, in such a manner that their beds are arranged in at least six nearly regular and parallel troughs.

In the upheaving of the strata along these severaal adjcent lines, the soft rocks of formation V, as well as the equally destructible layers of the limestone, which overlies it, have been subjected to a very wide spread action of the floods, which at one time evidently swept down from the neighboring mountains. The consequence has been, that the uppermost of these rocks, the limestone, formation VI, remains in but two narrow belts in Buffalo valley, composing in the one instance the limestone ridge south of Youngmanstown, and in the other, Dale's hill, directly west of Lewisburg. In each case, the preservation of the limestone stratum has been the result of the trough-like position of its beds, which has defended them from the currents that have carried away the more exposed portions of the rocks lying nearer the lines or axes of elevation. Where the trough or synclinal axis of Dale's hill crosses the Susquehanna, a narrow belt of formation VIII has, from this circumstance, been also preserved, the dark slate characteristic of the bottom layers of that formation, having been left about one mile north of the town of Lewisburg.

This undulating position of the rocks in Buffalo valley, accounts for the great width over which a single stratum, namely, formation V, is there spread out. By repeatedly bringing to the surface the same portions of the deposit, this circumstance greatly facilitate the search for any imbedded mineral layers, such as the fossiliferous iron ore of this formation.

But notwithstanding a long continued and minute examination of the rocks thus extensively exposed, the fossiliferous iron ore has, only in a few places been satisfactorily developed, while in no instance does it exist in a stratum of sufficient thickness to render it an object of much interest to the manufacturer of iron. No uncertainty can prevail respecting its position in the formation which agrees entirely, with that occupied by the thicker band of ore of Montour's ridge, now extensively worked. In one instance, in which we have met with this ore, namely, on the farm of Messrs. Dersham and Rank, about three or four miles from New Columbia, the apparent thickness of the ore was about seven inches, which is not sufficient to in-

duce any attempt at mining it. It was found in another case in the same relative position, to the beds of the red shale and sandstone formation, on the land of Aaron Chamberlain, but though the fragments of the ore are numerous on the surface of his fields, no layer of the mineral having much thickness has been discovered. Nearly one mile south of Lewisburg, along the river side, several thin seams from four to six inches in thickness have been found. They are very fossiliferous, being of the hard calcareous variety and would not justify the expense of mining them. The ore also occurs near Miller's saw mill, on Penn's creek, on the property of Robert Shippen, but as no excavation has yet been undertaken, its thickness remains unknown. Near this place there occurs a ferruginous bed of rather peculiar aspect. It consists of small particles of quartz, firmly cemented together by oxide of iron, and is between two and three feet in thickness.

Besides the fossiliferous ore now mentioned, which is peculiar to formation V, we have met with an entirely different variety in several places in the western part of Buffalo valley, occurring in the same formation, but to all appearance connected with the shales which occupy a rather higher position in the stratum, than the calcareous fossiliferous beds associated with the fossiliferous ore. This variety is a brown argillaceous ore, of a shelly and coarse honeycomb structure, its cavities being usually occupied by an unctious yellow clay, the predominant material of the soil in which it rests. An ore very similar in structure and composition occurs in our formation VIII, in Perry county, and a variety somewhat analagous, is to be met with quite frequently in the slates or shales of the bituminous coal measures of the western and northern counties, where the kidney ore has acquired nearly the same aspect at the outcrop of the strata, by the decomposing agency of the atmosphere. A mine of the kind of ore above spoken of, occurs about one mile south of Miller's saw mill, and has been somewhat extensively worked, Another deposit of the ore similar to the last in character and in its geological relations, occurs about six miles west of Millers'.

After the detailed examination of Buffalo valley, a few only of the results of which are here presented, were concluded, our explorations were extended to the mountains which skirt it on the west, afterwards to White Deer Hole valley, and subsequently to all that part of Lycoming county lying south of the base of the Allegheny mountain.

Moving forward in a southwest direction, we next entered Centre county, which was examined from the base of the Seven mountains to the base of the Allegheny, as far westward as the end of Nittany mountain. There remain, however, a few small neighborhoods in the district here specified, the true Geological structure of which were not fully ascertained for want of time. Some of these will be mentioned in this chapter. With these exceptions, the region designated has been, it is believed, adequately explored, its curious and highly intricate Geological structure unravelled, and some important advances made towards the laws which influence the distribution of its mineral resources.

I shall now describe as succintly as possible, the Geological features of the region explored, in order to convey more definitely some idea of the situation and extent of the several formations which it includes. A true knowledge of these features is indispensible to the successful tracing of any useful mineral deposites.

FORMATIONS INCLUDED IN THE DISTRICT EXPLORED.

Confining our present descriptions to the country south of the base of the Allegheny mountain, the formations of the portion of the district explored are, first, the great blue limestone of the vallies of Centre county or formation II; secondly, the slate, which in all cases skirts the margins of these vallies or formation III; thirdly, the sandstones or formation IV, which compose the Bald Eagle mountain and all the other high ridges south of it; fourthly, the red and variegated shales and sandstones or formation V, which have already been referred to as composing the chief part of Buffalo valley, and which occur also in White Deer Hole valley, and range along the northern base of the Bald Eagle mountain throughout the whole of its course; fifthly, the blue fossiliferous limestone or formation VI; sixthly, the fossiliferous sandstone, formation VII, a thin stratum in this region and sometimes entirely wanting; and lastly, formation VIII, all of which three latter rocks are confined to the vallies above spoken of, as containing formation V.

In the section of the country to which reference is now made, formations II and III are confined to the fertile agricultural vallies of Centre and Lycoming counties, which lie to the southeast of the Bald Eagle mountain. These vallies are, Nittany valley, Sugar valley, Little Sugar valley, Brush valley, Penn's valley and Nippenose

valley. In these beautiful and deep tracts between the mountains, formation II occupies nearly the entire surface. Formation III being a stratum of far less thickness, and usually dipping away from the limestone under the base of the adjoining ridges, is restricted to a narrow zone, begirting each limestone valley with a margin of slate The several beds of formation IV, constitute all the higher mountain ridges of the district, viz: the Bald Eagle mountain, the several branches of Nittany mountain, also White Deer mountain, Brush mountain, Short mountain and the long complicated range called the Seven mountains. Formation V spreads largely over Buffalo valley, and it occupies a belt in White Deer Hole valley ranging in another narrow tract to the end of Bald Eagle mountain, around the extremity of which it doubles to the westward, following the base of this ridge throughout its whole course by the valley of the Susquehanna river and the Bald Eagle creek.

Formation VI, has a more local range, it composes, as before said, the limestone ridge near Youngmanstown, and that called Dale's hill, both in Buffalo valley; and it is found in White Deer Hole valley, on both sides of the western termination of the Muncy hills, it occurs, besides, in an almost uninterrupted range near the middle of the valley included by the Bald Eagle and Allegheny mountains.

Formation VII, owing to its greatly reduced thickness in this part of the state, and to its very destructible nature, being a porous and loosely cemented sandstone, is more rarely to be seen, though it shews itself in places along the middle of the valley that lies northwest of the Bald Eagle mountain, in close connexion with the limestone just referred to.

Formation VIII, or the olive coloured slate and sandstone stratum, displays itself in a small patch in Union county, (consisting of only its lower beds,) in the neighborhood of Lewisburg. It also enters our present district forming the western portion of the Muncy hills, and occurs in a long and heavy belt two or three miles in width, skirting the southern or southeastern base of the Allegheny mountain, throughout its entire range, not only in Lycoming and Centre counties, but entirely across the State.

In order to have a correct conception of the Geology of the parts of Centre, Lycoming and Union counties, that have been examined, it is necessary to dwell, as briefly as possible, upon some of the leading features of the region. From the valley sometimes called

the Lewistown valley, which runs through the centre of Union and Mifflin counties, to the base of the Allegheny mountain, on the north west, the whole included broad belt of country, consists of a succession of nearly parallel, mountain ridges, remarkable for the straightness of their course, the even outline of their summits, the general similarity of their form, and their uniform height above the intervening valleys. Between these ridges we have a series of long, narrow and nearly straight limestone valleys, the southernmost of which is Kishacoquillas valley, in Mifflin county, while on the north west, are Nittany and Nippenose valleys, in a line with each other.

Now such is the necessary dependence of the Topographical features of any diversified region upon its Geological structure, or, in other words, so entirely have the present bold and singular outlines of this district, been impressed upon it, by the agency of causes strictly Geological, namely by the upheaving of the strata along certain lines and the simultaneous destruction of large portions of them, by the scooping action of a mighty flood, that we shall be much assisted in any effort to comprehend the intricate Geography of this region, by devoting a moment's attention to the following Geological views.

Of the seven formations enumerated above, as comprising the rocks of the portion of the State before us: formations II and III, are respectively a limestone and a slate stratum, which are at all times more destructible than sandstone: but especially so, must they have been in their soft or pulpy state, at the time of their elevation from the bed of the ocean, in which they were deposited. Hence they have been more deeply excavated than the harder ponderous beds of sandstone of which formation IV consists. We accordingly find formations II and III, always in the deep and nearly level valleys, and formation IV, in the high and steep mountain ridges. Of the other rocks, formation V, consists chiefly of soft slates and calcareous shales. Formation VI, of limestone, which like formation II, was evidently of a very soft consistence, when first uplifted, and formation VIII, of a mass of slate and argillaceous rocks. These would all be liable to very extensive destruction, whenever subterranean uplifting forces would bring them within the reach of those tremenduous currents, which those same uplifting actions set in motion.

It comports entirely with these views, that we find these destructible

rocks, restricted to the valleys or broad plains between the sandstone mountains. In the district before us, we see them confined to the Buffalo valley, White Deer Hole valley, and the valley at the base of the Allegheny mountain. Unless where formation VII, a sandstone stratum, dwindles to quite insignificant dimensions, it composes a steep and sharp ridge, though from its small thickness, this is always of unimportant height, when compared with the mountains that contain its more massive prototype, formation IV. These facts and others of a like character, are all important in their applications; affording us often the best clue in an unexplored or intricate district in tracing the distribution of any bands or deposits of mineral matter, which we may be in search of. Thus in traversing any portion of the district between the Susquehanna river and the Maryland State line, in quest of the valuable fossiliferous iron ore, peculiar to certain layers of formation V, it is of extreme advantage to trace the stratum by aid of the topographical features which belong to it, and to its contiguous formations, and it is only by understanding the connection between these features and the agents concerned in producing them, that we can with any success detect the stratum we are searching for, if any irregularity has thrown it out of its more ordinary position. The evidence of this will be manifest, in relation to the band of ore alluded to, when we come to another part of this report.

Bearing carefully in mind, therefore, the difference in the destructibility of the several rocks, while under the action of the currents, which have rushed across them with such tremenduous violence, sweeping off all their more exposed portions, let us advert to the operation of those subterranean upheaving forces which seem to have acted on the strata, with such resistless energy, uplifting, inclining and dislocating them in certain lines, which we now proceed to trace. By these two causes we shall account for all the features in the Geology and Topography of this intricate region. I shall, therefore, describe as concisely as possible the *lines of elevation* of the strata, or technically, the *anticlinal lines*, and at the same time the lines of *greatest depression* or *synclinal lines*, which range through the valleys and ridges of the district, and shall offer also a brief description of the Geology and mineral contents of the belts of strata, which they disturb.

NITTANY VALLEY AND ITS ANTICLINAL AXIS.

This valley properly speaking, commences at the southwestern extremity of Nittany mountain, where the broad Half Moon valley is divided by the mountain into this, its wider branch on the north, and Penn's valley on the south. It is bounded on the southeast, by the Nittany mountain, and on the northwest, by the Bald Eagle mountain. Where Nittany valley opens into the Half Moon valley, it is about six miles wide, but as we advance northeastward its width contracts to between four and a half and five miles opposite Bellefonte, and three and a half or four miles opposite Howard's gap, nine miles from Bellefonte, and to about two and a half miles opposite Millhall. Further east, the two converging boundaries of the valley unite, closing it up at a point nearly south of Dunnstown.

There is a central tract running through Nittany valley, between two and three miles in width, which is denominated the *Barrens*. It has a sandy and stony soil, is singularly destitute of water and remains therefore in its native uncultivated condition. It is here, that nearly all the large deposites of valuable brown argillaceous iron ore, which have rendered Nittany valley and its neighborhoods celebrated for their iron manufacture, are found. The surface of these barrens is considerably elevated, rising above the general plain of the valley into a ridge, which begins about two miles from Bellefonte, and extends eastward about twelve miles, where it subsides. From its termination eastward, to the head of the valley, cultivation extends entirely across from mountain to mountain. The features of this valley, indicate many departures from that more perfect regularity of Geological structure, which prevails in several of the other valleys of anticlinal form, which lie parallel with it, towards the southeast. The present report does not permit me, however, to discuss these local disturbances of stratification.

Though numerous irregularities in the dip of the strata prevail in some parts of the valley, they are inconsiderable, when compared with that general uniformity in the inclination of the beds, visible throughout its entire length. One great anticlinal axis runs through this valley from one extremity to the other. It is rather a portion of a still more prolonged axis of elevation, which is traceable from the neighborhood of Hollidaysburg, through the end of the Brush mountain, and thence along the Sinking Spring, Half Moon and

Nittany vallies, and still further through the middle of Nippenose and Musquito vallies and out through the end of the Bald Eagle mountain into the plain east of the Susquehanna, as far as Muncy creek. The position of this line from which the strata are tilted away in opposite directions, is not central through Nittany valley, except from the head of the valley to the neighborhood of Millhall. From this point southwestward, it is nearest the Bald Eagle mountain. All the strata which lie to the northwest of it, viz: the limestone beds of that side of the valley, the slate of formation III, which rests upon these and passes under the base of the Bald Eagle mountain, the sandstones of formation IV, of the same mountain, the rocks of the formations V, VI, VII and VIII, which occupy the valley between the Bald Eagle and the Allegheny mountain, all decline towards the northwest, with a greater or less steepness, the degree of inclination generally abating as we recede from the anticlinal axis to the slightly inclined rocks of the Allegheny. On the other hand the rising of the strata along this axis has caused all those situated to the southeast of it as far as the summit of the Nittany mountain, that is to say, the limestone beds of the southeastern half of the valley, the slate at the foot of the mountain, and the sandstone rocks of the mountain itself, to dip towards the southeast. The sandstone stratum, formation IV, dipping on the northwest side of the mountain, towards the southeast becomes horizontal along its centre, and displays on its southeastern side, an inclination in the opposite direction, or towards the northwest, so that the rocks of the mountain lie in a trough form, technically denominated a synclinal axis. Such is the structure of this mountain opposite Bellefonte, and throughout several miles of its length, towards its western extremity, but further to the northeast it becomes somewhat complicated, both in regard to the dip of its strata and its topography. Further eastward, in place of a synclinal axis or trough in the rocks, there is an anticlinal axis, the same which brings up the limestone in Big and Little Sugar vallies, which divides the mountain into two branches. As we advance still more towards the northeast, each of these branches of the mountain in its turn, becomes subdivided by other similar short axes of elevation. In consequence of these numerous parallel upliftings of the strata of this mountain, there are many alternations of dip in the rocks, from southeast to northwest, and hence the topography of the chain, being intimately dependent upon these circumstances, has acquired a highly complicated character.

Of the rocks of Nittany valley I have already stated, that the great blue limestone stratum of our state, formation II, occupies almost the entire surface of this valley, even capping in most places the sandy ridge, called the barrens. The character and quality of the rock, however, varies greatly in different belts. Beginning with the lowest beds visible, or those which have been brought to the surface by the movement of elevation acting along the anticlinal axis, we find immediately adjacent to this line, lying along the central ridge or barrens, many masses of sandstone, evidently derived from the underlying beds of formation I, but in no instance have we yet found that rock in place. In other parts of this central ridge, the limestone, formation II, shews itself, possessing in some degree the sandy composition of the inferior rock. Receding a little towards either side of the valley, or in other words, ascending into rather higher portions of the stratum, we meet a moderately thick body of tolerably pure limestone, which contains however, some layers of sandstone. Above this, there occurs a pale blue rock in numerous beds, having a very close resemblance to limestone, but singularly enough, containing little or no calcareous matter, being in fact, a very pure and fine grained siliceous rock, a species of compact chert, both in its texture and composition. The next belt in the ascending order, comprises a large body of very excellent limestone most generally of a very pale bluish aspect. In this, there frequently occur seams of white calcareous spar. Higher still in the formation, or indeed, in its uppermost subdivision, some of the beds are more or less bituminous, which they indicate by their fœted smell, some are decidedly argillaceous, manifesting a close approach to the immediately overlying slates of formation, III, and others are characterised by a profusion of fossil shells and other marine remains. These are the fossiliferous bands of formation II, at least in this region of the state.

The upper layers approaching to the slaty rocks of the next overlying formation III, contain a large amount of argillaceous matter. A little higher in the stratum, these beds alternate with numerous dark blue or almost black bands of calcareous slate, having a remote analogy in their appearance to those slates which lie in contact with seams of coal and consequently many abortive attempts have been made to discover coal in these rocks, not only in Nittany valley, but in the other limestone vallies which occur to the southeast, and even in many places in the great Kittatinny valley where these rocks are largely developed.

The soil derived from these dark calcareous slates which occur among the alternating bands interposed between the main masses of formation II and formation III, is deservedly esteemed to be among the most fertile in the state, being admirably adapted to the cultivation of wheat. This is well exemplified in the productiveness of some of the farms in the eastern part of Penn's valley, where the soil of a considerable tract of country has been derived from the source mentioned. The cause of its productiveness is obvious; while that from the slate is comparatively unproductive, owing to the excess of clay which it gets from that rock and to its almost total destitution of lime, and on the other hand, while that which rests upon the limestone, though of better composition and texture is scarcely more impregnated with calcareous matter, in consequence, probably of the facility with which the lime has been removed by the percolation of water through its open materials, the soil of these intermediate strata which have a sufficiency of lime in their composition, would appear to be perpetually replenished with this valuable ingredient from the facility with which the soft rock moulders down after ploughing and crumbles into mellow earth by the action of the atmosphere.

Formation III, which is a mass of fissile slate of various colors from light yellow and grey to dark blue and dingy olive, exists as a stratum of several hundred feet thickness, ranging in a belt along both the southeastern and northwestern margins of the Nittany valley, and extending commonly up the flank of each of the bounding mountains from a little outside of the base to within about one third of the total heighth from the summit. The lower layers, contiguous to the underlying limestone, are those which are most apt to be calcareous and to contain fossils, though these destinctive features belong also to some of the higher beds. In Nippenose valley some parts of this rock are highly fossiliferous, and the same remark will apply to the upper beds of the underlying limestone seen in that singular valley.

The strata of Nittany valley have been dislocated to an extent not witnessed in the anticlinal vallies which lie more to the southeast.—But the disturbances prevail almost wholly along the northwestern side of the valley, especially close to the foot of the Bald Eagle mountain. The irregularities in the dip of the rocks are traceable from Millhall, to nine or ten miles southwest of Bellefonte, and by observation made during a former season, I am led to think that they continue the whole way to the Little Juniata. The inclination of

the strata to the southeast of the main central anticlinal axis is never steep, rarely exceeding thirty degrees.

Though a great number of excavations for iron ore were visited in Nittany valley, many of which are highly interesting from the richness of the ore, and the prodigality in which the mineral is supplied, and from the curious features, seen sometimes in the deposits in their connexion with the underlying limestone strata, yet no satisfactory explanation has been arrived at concerning the origin of the ore, nor any general practical rule discovered, calculated to conduct us with a desirable degree of certainty, in a search after large deposits of the mineral. Some light has, however, been gained from other quarters of the state, through observations made upon the same formation. If these should be corroborated by future researches, some part of the obscurity which rests upon this difficult, but important subject, may perhaps be removed. For the present, I deem it premature, until the chemical examinations connected with the survey shall have been more advanced, to enter into the complicated enquiries arising out of the scientific investigation of our ores of iron.

FORMATION IV, AS IT OCCURS IN BALD EAGLE AND NITTANY MOUNTAINS.

The Bald Eagle mountain, the boundary on the northwest of the the three vallies of elevation, Nittany, Nippenose and Musquito vallies, consists of the sandstone rocks which constitute formation IV, uptilted towards the northwest, generally at a high inclination from the anticlinal axis, which traverses those three vallies in a longitudinal direction. From its eastern termination at the Susquehanna, near Muncy, the outline of its summit is remarkably level and regular, until we reach the eastern end of Nittany valley, where the profile of the ridge becomes rather more undulating, its line of direction less straight, and its heighth somewhat diminished, all natural results of the distnrbances near its southeastern base in Nittany valley. Between Musquito valley and the ending of the mountain at the river, it is a single ridge with a finely rounded summit and contains the anticlinal axis running centrally through it. But westward from that point its strata dip in but one direction or towards the northwest, and it exhibits throughout its whole length, two distinct parallel ridges with a considerable depression between them. These two summits are usually not more than a fourth of a mile apart, and possess

about the same elevation, though not unfrequently the northern ridge rises above the other, attaining a heighth nearly as great as that of any of the other mountains in the region.

By adverting to the nature of the rocks composing formation IV, we find a ready explanation of all the features of Bald Eagle mountain, applicable, not to this ridge alone, but to all the high ranges in the district which consist of this stratum. The formation embraces three distinct sets of beds; the uppermost and lowermost being massive sandstones, while the middle member is composed of soft argillaceous red sandstones and red slates. The lowest of these divisions is generally a grey sandstone, sometimes greyish or white and occasionally bluish, and in some ridges includes beds which are green in color and very tough. All these varieties are very hard, though the weathered fragments do not shew such sharp edges as those belonging to the upper division of this formation. Among these grey sandstones we find fossil remains of the Zoophytes, the class containing the corals, while in no instance have we met with these in the upper division. These lower strata of formation IV, compose the southeastern ridge of Bald Eagle mountain, and extending our remarks to the other mountains, they belong in general to that ridge which is immediately adjacent to the limestone valley, or in other words to the anticlinal axis. The sandstone beds grow less compact as we approach the middle part of the formation, and acquire a more greenish hue and become speckled with brown oxide of iron. The central division of the mass consists as already mentioned, of soft red argillaceous sandstones which are similarly speckled and interstratified with red slate. The upper member of the formation is a hard white and grey sandstone of even texture and often of extreme purity, easily distinguishable, if not recognized by its relative position to the other strata, by the frequent occurrence on its surface of a class of singular impressions formed by a marine vegetation called *fucoides*.

It is to the unequal destructibility of these three belts of rock, under the violent wearing action of a flood of waters which has rushed over their upraised edges, that we are to attribute the double ridge and the included valley on the top of the Bald Eagle mountain. The comparatively soft middle stratum, has been there scooped to a considerable depth below the more resisting sandstones which lie on either side of it.

In consequence of the triple character of formation IV, we in-

variably find the mountains that are composed of it, to consist of *two* ridges when the strata dip in the same direction, or when they contain no axis either anticlinal or synclinal. But whenever an anticlinal axis upheaves these rocks, exposing the lower sandstone, then the mountain contains *three* ridges, the axis of elevation being in the middle of the central one. And when, on the other hand, a synclinal axes or trough-like dip of the strata extends through the middle of a mountain, consisting of formation IV, it then contains *four* separate ridges, the two outer ones caused by the sandstone of the lower division, the two inner ones by the upper sandstone member of the same formation. Guided by these facts, which are the necessary results of Geological causes, we trace in the perplexing intricacies of the Geography of the mountain-chain, which passes through the counties that lie between Maryland and the Susquehanna river, the most beautiful symmetry in the structure and connexions of all the ridges. Were geographers, while mapping our mountain region, to make themselves familiar with the dependence of the configuration of the region upon its Geological structure, they would discover that the unerring rules of the science, constitute their surest or often their only clue, to those features of topography which it is their business to depict. The confusion and distortion, so conspicuous in our present maps, would give place to features of curious and pleasing regularity, and to accuracy of delineation now nowhere to be seen, while in the details, the benefits conferred by maps on the traveller, the engineer, and the miner would be tenfold enhanced. By adhering to the views above presented, we have been enabled to reduce to order nearly every part of the seemingly complicated topography of the mountain ranges, which embrace the Bald Eagle, Nittany, White Deer, Brush and Seven mountains, and their subdivisions, and to trace the existence or absence of particular mineral beds suspected to occur in these wild regions. We have thus succeeded also in collecting some valuable materials designed to correct the present map of the State, or to contribute towards the construction of a better one.

Omitting a description of the curious Geological and Topographical structure of the Nittany mountain, and its branches which would require the assistance of maps and profile sections of the district, not suited to the plan of the present report, I shall proceed to mention in few terms, some of the other parts of the region, and

to trace those axes of elevation which have imparted to each tract its particular Geological structure and mineral resources.

The anticlinal axis of Nittany valley, prolonged as before mentioned, to the eastward, has elevated the limestone rocks composing formation II, to the surface in Nippenose valley, causing the strata to dip at a gentle angle each way from this line, which runs nearly along the centre of the valley. This valley is remarkable for its regular oval form, being an ellipse of about ten miles in length and four in its greatest breadth, and for the height and steepness of the rim of mountains which encompasses it. The only avenue to it, without crossing a high zone of mountain land, is by a deep notch in the Bald Eagle mountain, nearly opposite Jersey Shore. The base of this notch, is on a level with the surface of the valley, and hence through it, all the waters which enter the valley find their exit into the Susquehanna river. It is a remarkable feature about the drainage of the valley, that the numerous streams which descend into it from the surrounding mountains, all disappear through the funnel-shaped depressions called sink-holes, which abound over the surface of the limestone stratum of this valley, and what is not a little curious, the whole united body of these waters gushes forth to the surface again, in a bold stream, passing through the mountain notch or gap, to which allusion has been made. A quarry of marble was opened and wrought with some spirit in this valley by Mr. Lawrence Wells. It is near John Bixler's tavern, three and a half miles from Rhodarmel's. The marble is a compact, dark, blue limestone, variegated by thin veins and specks of yellow crystalline carbonate of lime, or occasionally of white calcareous spar. The quarry has since been neglected. Layers, yielding similar marble, may be found near the centre of the valley east and west of this point.

Though minute attention was directed to the discovery of iron ore in this valley, the search has been to a great degree unavailing. Two circumstances discourage the hope of readily finding ore in any considerable quantity, first, the small depth beneath the surface at which we find the limestone rock; secondly the absence of that bright yellow stain in the soil, which is so good an index of ore in Nittany valley. The soil here is generally dark brown or reddish.

The next limestone valley of the district is Sugar valley, formed by an anticlinal axis which has uplifted to the surface, the limestone

rocks of formation II, between two of the branches of the Nittany mountain, a few miles east of the Bellefonte turnpike and which passes along the centre of Sugar valley to its termination, and thence through the middle of White Deer mountain to its end, where the axis leaving the ridge, passes out into the plain occupied by the higher formations of the series east of the river. In Sugar valley the strata on the northern side of the axis have a steeper dip towards the north than those on its southern side have towards the south.

Our researches for ore in Sugar valley have not been completed, having been interrupted by the snows at the close of the season. A furnace for smelting iron was erected some years ago, about five miles to the east of Kleckner's tavern, but though the iron manufactured was pronounced to be of superior quality, the supply of ore was insufficient to sustain the furnace. Of a number of excavations for ore which were visited, nearly every one seems to have been arrested at the depth of ten or twelve feet, by the underlying solid rock. This and other facts would appear to indicate a probability, that no extensive deposits of ore will be readily found in this valley, though further explorations are necessary to establish such an opinion. Sugar valley has an average breadth of nearly two miles, and is sixteen miles in length, the limestone which every where underlies it, being traceable to a point nearly seven miles east of Kleckner's. Between Sugar and Brush vallies, there are three distinct ridges, the middle and highest, containing a synclinal axis in the upper member of formation IV. Towards the eastern end of Sugar valley, the topography of the mountain bounding it on the south, becomes more complicated.

The anticlinal axis, next south of that of Sugar valley, lies in a ridge called Nittany mountain, from the eastern end of which it is traceable to the Susquehanna, which it crosses about three miles above the town of Milton. A much longer and more important anticlinal axis, which has elevated a beautiful and fertile belt of limestone, passes one mile north of Boalsburg, in Penn's valley and extends along Brush valley, pursuing the northern side, generally within half a mile of the base of Nittany mountain. It upheaves the strata of formation II, which dip at a moderate angle, rarely exceeding twenty degress. Running eastward, this line of elevation enters the middle of Buffalo mountain, which it traverses to its termination. It afterwards emerges into Buffalo valley where it inclines the red shale rocks of formation V,

and runs to the Susquehanna near New Columbia. Brush valley varies between one and two miles in width, is remarkably level, owing probably, to the gentleness in the dip of its strata, and is one of the most beautiful in the district. In consequence, probably of thesame cavernous character in the limestone, which exists to so great an extent in Nippenose valley, there is little or no water to be procured below the soil, in many parts of this valley by wells, and the inhabitants have been constrained to conduct it to their dwellings in pipes from the adjacent mountains. Brush mountain, consisting of all the three divisions of formation IV, is composed of three ridges, in consequence of a synclinal axis passing along its centre. This trough in the dip of the rocks, continues eastward into Buffalo valley, and extends westward into one of the Seven mountains at Boalsburg, passing a fourth of a mile north of Old Fort.

In Penn's valley, we can trace one anticlinal axis running between Egg hill and Brush mountain, and a second lying further south between Egg hill and the Seven mountains. The more northern of these lines of elevation, may be found about a fourth a mile from the foot of Brush mountain, near Millheim, and can be followed thence to where it passes about one mile south of the Old Fort, and onward until it enters the middle of a high knob of the mountain ending at Boalsburg, being there but a short distance south of the synclinal axis, that extends from the middle of Brush mountain. Towards the east, it has produced the valley in which Pine creek flows, and which lies between the Short mountain and Brush mountain, forming a northern branch to Penn's valley. From the end of this narrow valley, its course is through the ridge which terminates at the gap or entrance into the Brush valley narrows, whence it probably extends to the Susquehanna, crossing a quarter of a mile below Milton bridge.

The Short mountain is composed of three ridges, being a mountain of synclinal structure. This trough is continued under Egg hill, and thence into a ridge, which rises from the valley about five miles east of Boalsburg.

Following the anticlinal axis of George's valley, eastward, we trace it into Penn's valley narrows, between the Short and Seven mountains, and thence into a mountain which ends nearly three miles eastward of Hartleton. Westward this line of elevation in the strata, passes into what is called the Loop, and thence directly through the Bear meadows, and out into Stone valley.

Notwithstanding the seeming complexity in the geological structure and topography of the Seven mountains, this range is extremely simple. Crossing it, for instance on the Lewistown and Bellefonte turnpike, we discover the following features in the dipping of the strata, which belong to the three sub-divisions of formation IV. After leaving Penn's valley, the dips are first south, then north shewing a *synclinal* axis, and further still we meet a second change to a north inclination, giving proof of another *synclinal* axis. Passing over these last north dips, we reach the bold anticlinal axes, which have brought up to the surface the limestone strata of formation II. in Kishacoquillas valley. The trough or *synclinal axis*, first met with south of Penn's valley on entering the Seven mountains, passes into Buffalo valley north of Paddy's mountain. This mountain contains an anticlinal axis, the same which forms the middle ridge of the Seven mountains. The southern synclinal axis or trough in the Seven mountains may be traced through Buffalo valley, along the middle of Limestone ridge, to the Susquehanna, nearly three miles south of Lewisburg, whence it may be prolonged immediately to the south of the anticlinal axis of Montour's ridge, though it probably dies out at the river. The axis of elevation just mentioned, after leaving Montour's ridge, continues westward in Buffalo valley, and dies out between Paddy's and Jack's mountains.

Kishacoquillas valley, a limestone valley of great beauty, and interesting for the abundance and purity of its iron ores, contains probably three anticlinal axes, though only two are traceable beyond it, northeastwardly into Buffalo valley. One of these axes of elevation passes between the Seven mountains and the northern knob, which closes the valley towards the northeast. This knob contains a synclinal axis or trough in formation IV, and includes near its end three ridges, and further eastward four, by the forking of the middle ridge, which consists of the upper or white sandstone member of formation IV. The most northern of the two inner ridges after running some distance, is joined by a similar ridge from the southern part of the Seven mountains, and the two closing into one mountain, form the White mountain with an axis of anticlinal structure. Its axis is prolonged through Buffalo valley, where it may be traced along Penn's creek, and further still into Longstown ridge. The point at which it is finally exhausted or what is the same thing, where the uptilted strata finally flatten down or change their dip, is not yet exactly known.—

The anticlinal axis which extends along the southeast side of Kishacoquillas valley, passes eastward between another knob at the head of the valley and Jack's mountain. The upper strata of these two close together over this line of elevation, which thence runs through the centre of Jack's mountain. This ridge has, therefore, a simple anticlinal structure from hence to its termination, two and a half miles west of New Berlin. At this point of the mountain it has gently elevated the shaly strata of formation V, affording us an opportunity for finding the fossiliferous iron ore, not only around the end of Jack's mountain, but along both the northern and southern flanks of the ridge, should it exist here in any conspicuous quantity.

Having endeavoured in the foregoing account of the Geological structure of the parts of Union, Lycoming and Centre counties explored during the past season, to convey as far as my present limits allow, some conception of the mode in which the formations in this quarter of the state are distributed, I shall conclude what I have to say on the third Geological district, by describing as briefly as possible, the several belts of formation V, in its range between the Susquehanna river and the Maryland state line. I am induced to do this from a persuasion of the great importance to our iron manufacture in these counties, of the fossiliferous iron ore which occurs only in this fifth formation. I wish also, to place on record at this time, some information respecting the range of the ore, in the hope that it may prove useful in directing the researches of the proprietors of furnaces, and others interested in the discovery of the mineral. The detailed and systematic examination undertaken for this highly valued species of iron ore consumed aconsiderable portion of our season in Buffalo and White Deer Hole vallies, and the valley of the West Branch and Bald Eagle creek from Muncy to Bellefonte. Hereafter, it will be extended to every belt of the red and variegated shales which offers any reasonable indication of containing the fossiliferous ore. It may be expedient in the mean while to state results of various reconnoissances in parts of the district not yet accurately surveyed, by which the wide distribution of the ore has been established, and the directions in which it ranges at least approximately ascertained.

Before tracing the course of formation V, it may be useful to call attention to the part of the stratum, in which the fossiliferous ore occurs, referring for more minute details to my second annual report. The whole stratum consisting of red and variegated shales, and red

sandstone, is susceptible of a natural sub-division into three members. The lowest of these is a dense and heavy sandstone of a dark brown color, having a decided tendency in its fragments to assume a square or cubical form. The middle division is made up of layers of shale or soft slate of various tints, the more usual colors being dull olive, bluish grey, yellow or buff, and dingy brown. Some of these layers, especially the olive colored ones, are often covered with the impressions of shells and other fossils. In this part of the stratum, those are also, occasional thin bands of limestone, generally highly fossiliferous layers, that the bands of fossiliferous iron occur in, whenever they are present. The upper sub-division of the stratum, is a rather thick mass of red or rather brown shale, of very crumbling texture and uniform aspect.

Upon formation V, the next in the order of stratification, is the blue fossiliferous limestone stratum, formation VI, of the series.

In consequence of formation V, reposing on the great sandstone mass, formation IV, its lower and middle beds will be found to be almost invariably upon the flank, or at the base of the high mountain ridges, consisting of the latter stratum. This will always be the case, when the inclination of the rocks is considerable. In those instances where all the strata of the mountain dip, in one direction, for example, in Bald Eagle mountain, the ore bearing stratum or formation V, will be found only on one side of the ridge, namely: the side remotest from the anticlinal axis, which has produced the elevation of the mountain, which being here, the Bald Eagle mountain, the axis is that of the Nittany valley. But in other cases, where an anticlinal axis passes along the summit of the ridge, composed of formation IV, or in other words, where the rocks dip in both directions, from the middle of the mountain, then there occur two belts of the ore, or at least of the stratum in which it alone exists. Such is the structure of Montour's ridge, in Columbia county, where a distinct band of the ore occurs along each flank, running for a distance of many miles. A similar conformation prevails in Wills' mountain, in Bedford; Jack's mountain, in Huntingdon; Shade mountain, in Mifflin and Union; and Tuscarora mountain in Perry county. The presence of the ore is indicated along nearly all of these ridges, but too little has hitherto been done, in the way of a systematic exploration, to authorize my entering here into any further particulars, than to trace out the course of the formation which should contain

the ore. Commencing with its most northwesterly belt, in the district and indeed in the State, we can trace formation V from the eastern end of Bald Eagle mountain, along the northwest side of that ridge, at the base, and upon the flank of which it reposes throughout its entire course, to its southwestern termination near Hollidaysburg. In all this distance, the dip of the stratum with a very few local irregularities, is towards the north west, with various degrees of steepness. Here passing round the point of the mountain, the formation spreads out as far as that town, when the fossiliferous ore is sometimes met with in excavations, but its want of thickness, and the excess of calcareous matter which its numerous fossils give it, have prevented its becoming an object of economical interest. From Hollidaysburg the formation containing the ore, having doubled round the end of the Bald Eagle mountain, which is here called Brush mountain, ranges northeastward to the head of Canoe valley, at the junction of the true Brush mountain with Canoe mountain. In this portion of its course, the prevailing dip of the stratum is towards the southeast. From the head of Canoe valley, it courses to the southwest, along the northwest base of the Canoe or Lock mountain, running into the little cove of Old Town run, thence northwestward towards Frankstown, before reaching which it folds round the end of Dunning's mountain, (here called Lock mountain,) and pursues from this point southward, the western flank of that mountain, to its termination about eight miles north of Bedford. Folding round the spur which Dunning's mountain here throws forward to the south, one belt of the formation obeying the flexures of the mountain sweeps round the margin of the valley, termed the Dutch corner and continues its course thence along the western base of Evitt's mountain, (the prolongation of Dunning's mountain,) to the Maryland State line. The other belt passes on towards the southwest, or if interrupted it is only for a short distance, and encounters the northern end of Wills' mountain. In virtue of the anticlinal structure of that ridge, the belt is here divided into two, one taking the eastern base of the mountain along the Cumberland valley, the other the western base following the valley of Wills' creek. Both of these tracts of formation V, cross the Potomac into Virginia, whence they are prolonged more than one hundred miles in connexion with the same great anticlinal axis. From information derived from the State Geologist of Virginia, Professor WILLIAM B. ROGERS, the

same valuable fossiliferous iron ore, which imparts such interest to this formation in Pennsylvania, still accompanies the stratum, being met with in beds from six to eighteen inches in thickness, and of very pure composition.

As an evidence of the probable continuousness of the ore throughout the long tract between the Susquehanna and the Potomac just traced, it is proper to mention that a bed of sufficient thickness for valuable purposes occurs in Dutch corner, and one has likewise been found near Frankstown, where the ore is used, making a very excellent iron.—Commencing at our former point of departure, at the eastern termination of Bald Eagle mountain, on the Susquehanna, we may trace the formation in a very irregular and winding tract southeast of that already described. This belt extends from the river, with a southeastern dip, along the south branch of the Bald Eagle mountain, to the head of White Deer mountain. Folding back, it doubles round the end of this mountain axis near Watsonburg, entering Buffalo valley, over the surface of which it expands itself as previously described. The lower beds of the stratum take a winding course round the margin of the valley, running up a short distance into the vallies which head between the several anticlinal ridges that project themselves forward into the main valley, and doubling round these, where they die away upon the plain. Following this curving course, these rocks reach the head of Buffalo valley, whence we may trace them eastwardly by the valley of Penn's creek, with a north dip resting against the base of Jack's mountain. Sweeping round the eastern end of that mountain, they assume a change in their dip to the south, conforming to the axis of elevation in the middle of that ridge. The belt next runs southwestward along the southeastern foot of Jack's mountain, obeying the gradual flexure of the ridge until it reaches its southern extremity in Huntingdon county. This mountain containing an anticlinal axis at its southwestern end, as it does at its other extremity in Union county, the overlying stratum, formation V, mantles round the terminating knob, as it must round that of every similar anticlinal ridge, composed of formation IV, and taking an altered dip to the northwest, it follows the western flank of the mountain, and its continuation, Stone mountain, to the head of Stone valley. The border of this valley being diversified towards its upper end, by several mountain knobs protruding themselves into it from the northeast, these short and rapidly subsiding ridges as we have already beheld in

which form the mass of the mountain. After seperating at this point, which is a few miles east of the Juniata river, one belt pursues its course to the southwest along the northwestern flank and base of the Tuscarora mountain, the curvatures of which it follows as far as Sidney knob, in Bedford county. On the western side of that ridge the formation disappears in consequence of an enormous dislocation of the strata, which commencing in this vicinity, runs southward along the western foot of Scrub ridge, tilting its strata and those of the adjacent side of the M'Connelstown cove, (composing formations III and II,) which it borders into an adverted position, and burying the rocks of our formation V, and also, the overlying formations VI, VII, and VIII, so that the strata of formation IV, actually lean in some places upon those of formation IX. This has thrown down the ore bearing shales of formation V, to a depth of probably not less than three thousand feet below the surface which they would otherwise occupy.

Further to the south, in the neighborhood of Hanover furnace, the dislocation seems to become less and these rocks once more emerge to the surface, forming a narrow belt in which their strata are greatly crushed. This, however, after a course of a few miles, crosses the state line, and finally, the Potomac river below Hancock.

The other belt of formation V, taking the southeastern side of t' Tuscarora mountain, ranges with southeastern dips along its base through Raccoon valley, and in the same general course, follows the mountain nearly to the line of Perry and Franklin counties. There the stratum is caused to curve much about, sweeping round the points of the high ridges in that part of Perry, and winding into the short valleys between these knobs. It then stretches eastward until it nearly reaches the town of Bloomfield, and thence ranges southwestward, meeting finally, after several meanderings the northern base of the Kittatinny or Blue mountain, near Wagner's gap. From the latter point it follows the northern slope of this mountain, to the Susquehanna, whence it ranges northeastward as described in my last annual report, resting at the base of that ridge until it leaves the state, near the Water Gap of the Delaware river. Fragments of iron ore indicating the probable existence of the fossiliferous band, were picked up at several points when making the reconnoisance of Perry county, but in the belt which stretches from the Susquehanna to the Delaware, along the base of the Kittatinny mountain, notwithstanding a diligent

examination has been made, no symptoms of its presence in any quantity have been discovered. Its absence from this, which is the most southeastern tract of the formation, is probably attributable to the almost total deficiency of the variegated calcareous and fossiliferous layers in the middle of the stratum, with which the ore would appear to be invariably connected.

The only other exposure of formation V, in the state is upon Montour's ridge, and here the fossiliferous ore is largely developed and at present somewhat extensively worked. A general account of it, sufficient for the present purpose, was offered in my last report. In closing this chapter upon the third Geological district of the state I would observe that the reader is by no means to infer that the formation, thus extensively distributed, and which I have approximately traced, is the only one besides the great blue limestone, formation II, that holds out a promise of containing iron ore in sufficient deposits to warrant a minute exploration. Valuable ores peculiar to each stratum, are often found and occur sometimes rather abundantly, in connexion with formations VI, VII, VIII, IX, and XI, and with the coal measure, of Broadtop mountain, embraced within this district. By following up the detailed investigation of all the strata of the region upon the plan already commenced, we hope ultimately to offer to the manufacturers some valuable facts concerning the best clue to the position of these ores. General practical rules in relation to the distribution of so important a mineral if discoverable, are of inestimably greater benefit to the public, than almost any number of merely insulated discoveries, and that they are often attainable by the aid of careful observation and science, must be conceded by every one at all experienced in mining and Geological research.

CHAPTER III.

A GENERAL SKETCH OF THE OPERATIONS OF THE SURVEY IN THE DISTRICTS NORTH AND WEST OF THE ALLEGHENY MOUNTAIN.

SECTION I.

That part of Pennsylvania which lies to the north and west of the Allegheny mountain, comprising about one half of its territory, exhibits a remarkable contrast to the Appalachian chain, which I have been last describing, both in respect to its Geology and its Topographical structure. The strata of its rolling surface belong only to the four or five uppermost formations of our great lower secondary series, whereas in the Appalachian region, we are presented with every rock of the entire group, from formation I, to the coal measures or formation XIII, inclusive. Here those two great natural agents which have given to every part of our country, all that is peculiar to it in its external Geological and Geographical features—I mean the subterranean forces and the superficial ones—have evidently operated with far less intensity than in the disturbed mountain chain which borders this region on the southeast. In the country which I am now about to describe, the inclination of the rocks is much less, and the changes in the direction of the dip more rare, in other words, the anticlinal axes are flatter, fewer and wider apart, though they preserve their general parallelism. The operation of currents upon the strata would also appear to have been more gentle and evenly diffused, and individual strata have been preserved from destruction, and keep their position near the surface over far wider areas, than in the other region, so that whatever useful mineral deposits they may contain, such as beds of ore or seams of coal, will be found spread out over an extent of country, so great, as hardly to be credited, unless we advert to the causes which have occasioned their being thus diffused. One of the most fortunate circumstances for the resources of this portion of the state, arising out of its peculiar Geological structure, is to be found in the universally rolling outline of its surface, which is every where trenched by ravines, and by more or less deep vallies, the results of an

extensive denudation by water. This feature gives us ready access to the strata and all their contents, which lie above the lowest water level of the country, imparting superior exactness to our explorations by the facility afforded for inspecting and measuring all the beds. In entering upon a brief, general description of the mode in which the mineral wealth of this part of our state is diffused a hasty outline of its leading Geological features, will prove a useful introduction to the details which are next to follow.

Taking a comprehensive view of its stratification, the whole of this northwestern half of the state, has the structure of an extensive basin or more properly it is the termination of a more enormous basin, which stretches southwestwardly from Pennsylvania to the northern border of the state of Alabama. From the southern boundary of the state, in Somerset county, to the North Branch of the Susquehanna, in Luzerne, the southeastern base of the Allegheny mountain, constitutes a remarkably well defined margin, separating this region from the Appalachian chain. Between that limit and the shore of Lake Erie, on the northwest, and the state of New York, upon the north, the strata all belong to formations VIII, IX, X, XI, XII and the coal measures or formation XIII. The two lowest of these rocks, formations VIII and IX, ranging along the southwestern foot of the Allegheny mountain, between the points already designated, sweep in a wide curve round the eastern terminations of the upper rocks in Susquehanna and Bradford counties, and are traced westward in a long belt, parallel with the northern line of the state, from Towanda to the state of Ohio.—Immediately within the long zone thus delineated, we perceive a bold escapement formed by the hard sandstone strata of formations X and XII, being the actual margin of the great bituminous coal basin.

On the southeast this escapement is the ridge of the Allegheny mountain, but on the north, it is a more indulating chain, of more broken outline, which stretches from Towanda, almost due westward by Blossburg, Smethport and Warren, and thence with a greatly reduced height, is deflected somewhat to the south by Meadville and Greenville, until it crosses into Ohio. Along the northern side of the basin from formation VIII, upward in the series to the coal measures inclusive, the strata have a gentle dip towards the south, leading us into higher and higher beds of rocks, as we recede in that direction from the New York line, where the slate and argillaceous sandstones of formation VIII, form the predominant rocks. In Crawford and Mercer

counties, where the lower strata lie to the northwest of the coal, the prevailing dip of all the rocks of the series is towards the southeast, but along the Allegheny mountain, or on the southeastern margin their prevailing inclination is either northwestward or northward, being thus in every case inwards, as respects the central portion of the great trough enclosing the coal. But while this as a general rule, holds strictly true of the strata along the edges of the basin, it is necessary that we should observe, that within this boundary there exists a number of anticlinal axes, some of them of great length and elevation, others low and insignificant, which give to the strata throughout nearly the entire region, an almost endless succession of more or less gentle undulations. As those axes of elevation have lifted the formations that lie below the coal to the surface, even causing the latter to be swept away entirely, over many considerable tracts of country, and as they in fact divide the whole region into a series of insulated and subordinate coal basins, the exact limits of which it is important, I should mention, I shall briefly describe the position and range of such of those as our researches have brought to light, specifying some details about the strata in the several basins which they enclose.

SECTION II.

OF THE FOURTH DISTRICT, EMBRACING THE COUNTRY INCLUDED BETWEEN THE BASE OF THE ALLEGHENY MOUNTAIN, AND CHESNUT RIDGE.

Nearly all of the anticlinal axes which are of sufficient magnitude to impress decided features on the topography of the region, or to have caused the removal of the coal measures from along this line, range in a northeast and southwest direction, or in lines parallel to the course of the Allegheny mountain, and are embraced within a belt of country rarely exceeding forty miles, in width, measured northwestward from the base of that escarpment. Beginning with the southern end of this belt, where these anticlinal axes, and their included troughs containing the coal measures are best defined, and where our explorations as far as relates to the southeastern counties of the great coal field, have been more detailed than further north, the anticlinal axis which first meets our attention, west of the eastern margin of the coal, is one which occurs midway between the Savage

and the main Allegheny mountains in the southeast corner of Somerset county. This is probably a prolongation of that which ranges along the summit of Chesnut ridge, in Bedford county, where it has brought to the surface the limestone and sandstone formations, VI and VII. As it ranges towards the southwest, it exposes the rocks of formation VIII, which form a long wedge shaped belt, ending near the line of Southampton township. From this point, where the belts of formation IX, on each side of it have coalesced into one, this latter stratum, alone occupies the depression between the two mountains above named, a less extensive denudation of the rocks which fold over the axis, having taken place towards the south of the two separated edges of the higher formation X, which forms the ridges of the great Allegheny and Savage mountains. These unite, and as we approach the Potomac, they compose but one mountain, along whose summit we may still trace the prolongation of this anticlinal axis. It is this axis of elevation, which together with that of Wills' creek mountain, the westernmost of those in the Appalachian region, to the east, forms the highly interesting and important coal basin of the Potomac. This basin commencing towards the head of Stone run, in Hardy county, Virginia, ranging through Maryland, and terminating at Wills' creek, in our own State, is here bounded on the east by the little Allegheny, and on the southwest by the Savage mountain. The Pennsylvanian portion of this basin may be estimated at five miles in width, measured along the State line, and seven in length. It is believed that no coal will be discovered to the northeast of Wills' creek, as from the close approximation of the bounding ridges, the coal measures have there been much exposed to denudation and carried off. Of the coal veins enclosed within this trough, the highest in the series is that which is principally worked. It extends with a very undulating line of outcrop near the summit of a long irregular ridge of considerable elevation, lying about midway between the little Allegheny and Savage mountains. Numerous transverse valleys of denudation intersecting the ridge, have interrupted the regular range of this upper coal seam, rendering it difficult to compute the area which it actually occupies, but favouring greatly the operations of the miner, to penetrate it by exposing a more extensive out crop. Its average thickness, as ascertained in numerous places where it has been opened, is about eight feet, the most extensive mine being that of David Hoyman, about a mile northeast of Jenning's run.

The identity of this, with the great seam worked at Frostburg, in Maryland, is highly probable, as well from the character of the coal itself and the accompanying shales, as from the similarity of its position upon the ridge. Several other good seams are known, situated lower in the series, in thickness from three to five feet, but being less accessible and important than the one above, and there being at present but a small demand for coal in this neighborhood except for local use, they have excited but little attention. Iron ore of excellent quality was collected by us on the surface, at many points in the basin, and there is reason to believe will be found in ample quantities especially associated with the shales of the lower seams, whenever the proprietors of the soil shall deem it of sufficient consequence to undertake the requisite diggings. Between the coal seams there occur two or more thin bands of limestone sufficiently abundant to use as a flux or for agricultural purposes. The tract included between the Savage and Allegheny mountains, containing formations VIII and IX, thrown up by the anticlinal axis previously traced, presents but little that is interesting in regard to its mineral resources. The rocks of the Allegheny mountain thrown into northwest dips by this axis, are thus made to constitute the southeastern margin of another basin, whose northwest boundary is defined by the rocks of the Negro mountain, which have received a contrary dip to the southeast, by an axis passing through the centre of that ridge. The broad and flattened axis of Negro mountain, exposing formamation X on its summit, and over its gently inclined flanks, is prolonged to the northeast, at least as far as the Bedford and Stoystown turnpike. Along this elevated belt therefore the coal bearing rocks have been removed, and at the same time the influence of this axis, by elevating the strata in the middle of what would have been a broad and deep basin, between the Allegheny mountain and Laurel hill, has rendered the two minor basins into which it has divided that space comparatively shallow, and removed much coal.

A tract of rather low ground follows the northwestern base of the Allegheny mountain, in the southern part of Somerset county, from which the coal measures appear to have been removed by deundation, but the coal almost invariably occurs in the first range of hills further towards the centre of the basin. Thus in the vicinity of Salisburg, little or no coal is indicated between the mountain and Castleman's river, while it is abundant in the higher lands, to

the west of that stream. In this neighborhood, as in the south east basin before described, the best developed coal seam the large one, being here from eight to nine feet in thickness. Though traceable over a considerable extent of country, it has hitherto been opened in only a few places, there existing at present, but little inducement for mining the coal, secluded as it now is from market. The lower and thinner coal beds, and the iron ore often associated with them, have therefore, been still less sought for, and are scarcely known. Advancing northward to the neighborhood of Berlin, we there no longer meet with the upper or larger seam, a deeper denudation of the strata, having washed it away, but the lower seams have been wrought near the town to some extent, for the supply of Berlin and Somerset. At this place the seams which are mined are three in number, the uppermost affording about 5 feet of true coal, the middle one, considered the best, and hence most worked, about 4 feet, and the lower one recently opened about 3 feet. The space between the upper and middle beds, measures about 60 feet, that between the middle and lower beds from 40 to about 50 feet.

In some of these shales between the coal seams, occur thin flaggy bands of iron ore of considerable purity, being an argillaceous proto-carbonate of iron. There likewise exists a bed of limestone nearly three feet in thickness. Iron ore prevails about Elk Lick creek, near Castleman's river, and may be observed in many places along the northwestern declivity of the Allegheny mountain.

Near the base of the same ridge, bog ore may also be frequently found, but the deposites rarely give evidence of a large supply. The occurrence of one or more layers of limestone in the strata between the lower coal seams, is an usual feature in nearly every part of this basin, and from the inestimable value of lime in agriculture, it is to be regretted that more frequent use of it is not made.

Between the northwestern slope of the Negro mountain, and the southeastern flank of Laurel hill, occurs the next trough of coal measures. These upper strata dip gently to the northwest, from the former of these ridges, and at about the same inclination to the southwest from the latter, conferring upon the valley between them, the structure of a regular synclinal basin, of rather wider and deeper dimensions, as respects the coal containing rocks, than that embraced by the Negro and Allegheny mountains.

The townships of Addison and Turkey Foot, lying within this

trough, have a rough and hilly surface, intersected by rivers and streams, which run in deep gorges between the hills. Towards the centre of the basin, the seams of coal usually occupy a low position, being rarely exposed, but in the deep ravines, and near the borders of the streams; a coal seam six feet in thickness, is found low down on the banks of the Youghiogheny, near Smithfield, from which a considerable quantity of coal is derived for the supply of that town.

The exact position of this bed in the series and the relative situation therefore of the other seams to it, has not yet been ascertained in this neighborhood, but further research, it is hoped, will make these matters clear. Iron ores exist in many places within this basin, and could probably be procured in ample supplies, for the manufacture of the metal, especially towards either border of the district, if those who are interested, would embark in some systematic diggings, among the slates connected with the lower coal seams. About Drake's run, and from thence towards the head of Laurel hill creek, it would appear to prevail in great abundance, and much of it to be of excellent quality, but occurring in a wild and uninhabited region, it has been but little sought after. Near the head of Garey's run, it is procured for the use of Rogers' furnace, to which it is taken to the western side of Laurel hill. Exploring the country northward towards Milford and Somerset, we find coal abundant in the hills lying west of Castleman's river, but extending our researches still further north, we observe the surface of the country, gradually to rise and to be less intersected by the valleys and ravines, so essential to the full exposure of the strata, and as a consequence, the indications of coal become more rare. Between Somerset and the base of Laurel hill, very little coal can be detected, though the probability, if we judge from the dipping of rocks, and other indications, is great, that the main coal seams have not been washed away, but lie buried beneath the more unproductive strata that occur near the surface. The same remarks are true of the country north of Somerset, until we descend to a considerably lower level along the waters of Stony creek and Quemahoning, where we again find the coal. In this position, it occurs near Stoystown, and further westward, and also eastward on the other side of the prolongation of the Negro mountain axis, which is here greatly reduced, or possibly, entirely flattened down; and again, on

the flank of the Allegheny mountain, at Statlers on the Bedford and Stoystown turnpike. This vanishing of the Negro mountain axis, causes the whole valley between the Allegheny mountains and Laurel hill, to have the structure of a single basin, and from Stoystown northward, I shall speak of it as one. Iron ore, apparently of fine quality, is found along Stony creek, above Stoystown, and also, in many places near the foot of Laurel hill, on the head branches of Quemahoning. That at the old Shade furnace, is rough and sandy. This furnace has not been in blast for some years. From the vicinity of the turnpike, above spoken of, northeastward, to the Conemaugh, the country is rugged and unsettled, except in a few spots in the neighborhood of Paint creek. Near the mouth of that stream, and along the valley of Stoney Creek, where some population prevails, the beds of coal are again recognised and have been partially mined at a few points, to supply the blacksmith's and others in the district. The digging of the coal being performed, as in most other similar places, during the winter, and carried on upon a very small scale, the spring thaws cause the earth and slates to fall, rendering the entrance to the mines, inaccessible during the summer. We are thence, too frequently precluded from ascertaining the thickness, quality and aspect of the seams, and from procuring those other data, so essential to any attempt to trace and develope the coal over the circumjacent country.

The deep valley of the Conemaugh, exposing the strata from the uppermost beds of the coal series, in this part of the basin, downward to nearly the bottom beds of formation XI; we are enabled, through a careful examination of the denuded beds, to determine with some accuracy, the contents of the coal formation in this portion of its range. The artificial excavations along the line of the Portage rail-road, furnish from point to point, displays of the stratification, which greatly assist the investigation. Using the facilities thus afforded, we collected an ample suite of specimens, from the strata composing the coal measures, together with a set from the under-lying beds of all the formations, included between the base of the Allegheny mountains and the first bed of coal. Minute measurements were at the same time instituted, which will enable us to approximate to the thickness of all the strata, between the foot of the mountain and the third principal coal seam, which rests upon its summit. The same was done in the gap at Laurel hill, where the Conemaugh pas-

sing through that ridge, presents an excellent opportunity for collecting those details of the stratification, which when applied to other neighborhoods, where the rocks are more obscurely discovered, greatly assist us in tracing any valuable beds, which they may contain. In the vicinity of Johnstown, there are known at present, three seams of coal, the lowest occurring only a few feet above the level of the Conemaugh. The next is between forty and fifty feet higher in the strata, and has immediately beneath it a stratum of limestone, varying from three to eight feet in thickness. Between sixty and seventy feet above the middle coal bed is another, apparently the uppermost workable seam in this vicinity. These coal beds are respectively three, three and a half and four feet in thickness. They are but little worked, supplying only the immediate neighborhood. The mines adjoining the rail-road on the Allegheny mountain, furnish fuel to the stationary engines at the inclined planes, and supply a moderate demand from the country east of the mountain. The measurements and other researches undertaken, indicate that most, if not all these mines near the rail-road, are in the uppermost of the three seams already mentioned, excepting the mine of Dr. Shoenberger, near the foot of Plane, No. 6, on the eastern descent of the mountain, which would appear to be in the lowermost bed in the series. Passing from the valley of the Conemaugh, towards Ebensburg, the surface of the country rises rapidly, and the principal coal seams are again lost to view, beneath the unproductive superincumbent strata, which here spread themselves over the surface. Some small beds from one to two feet in thickness, are however met with. Towards the eastern and western borders of the basin, near the base of the Allegheny mountain and of Laurel hill, the lower and thicker beds, occasionally show themselves, and admit of being extensively traced.

Among the slates included between these seams, we find as usual, the chief deposites of argillaceous iron ore, the display of which is particularly promising along Laurel run and Hengston's run, which flow southward into the Conemaugh, near the foot of Laurel hill. Ore is also to be found along the waters of Clearfield creek, and in other places, near the Western slope of the Allegheny mountain, between eight and ten miles southeast of Loretto.

Northward from Ebensburg, the country descending in virtue of the drainage towards the Susquehanna, we once more cross the out crop of the coal, though in this truly wild forest region, but very

little excavation has been attempted. The Laurel hill looses its features as a distinct ridge, a little south of Blacklick creek, the anticlinal axis to which it owes its elevation and structure, being hardly discernable in the deep gorge through which this stream flows across its termination. Some miles south of this point, the height of the ridge being much reduced and its axis greatly flattened down the coal slates and the coal itself reach high up on the irregular, but gentle slope of the hill; at the extremity of the ridge, coal is found in abundance exposed in the valley of Blacklick creek, whence it is taken chiefly to the town of Ebensburg. Iron ore, also occurs, and a considerable amount of excavation has been made in search of it, on the north bank of the same stream, through the enterprize of Messrs. Lewis and Rogers of that town, and with encouraging prospects. About two miles lower down the stream, borings were made some years ago into the strata and salt water obtained, but the manufacture of salt was abandoned. Recently, operations in this place have been recommenced, by Judge Murray of Cambria county, whose workmen during the autumn, were engaged in increasing the depth of the wells.

The next coal basin of which I propose to offer a brief sketch, is the long synclinal valley, enclosed by Laurel hill, on the southeast, and Chesnut ridge on the northwest. A straight and very regular anticlinal axis, extending along the centre of each of those important ridges, the rocks on the northwestern side of the Laurel hill, are made to dip towards the northwest, while the same strata appearing along the southeastern base of Chesnut ridge, incline in the contrary direction, or towards the southeast, giving to the whole belt the structure of a regular trough. To this feature, we owe the preservation of the upper or coal bearing rocks, which have been swept entirely away, from the denuded flanks and summits of the two bounding ridges. It may be well to mention in this place, that a singular degree of confusion prevails, in regard to the name of these ridges. From its northeasern termination, to the break or notch, by which the Youghiogheny passes through it, the ridge is every where stiled the Chesnut ridge, but from that point southwestward into Virginia, it often, though incorrectly, receives the name of Laurel hill. In my descriptions, I shall apply the name of Chesnut ridge to this axis, throughout its entire length, and reserve that of Laurel hill, for the mountain which ranges parallel with it on the southeast, at an average distance of twelve miles.

In the western corner of this coal basin, included between these ridges and bounded by the state line and the national road, some of the coal seams show themselves, being mined in a few places on a small scale, for fuel for the blacksmiths. On the bank of Sandy run, a little north of Elliott's mill, there occurs a natural exposure of Iron ore, which from the apparent quantity of the mineral deserves attention. The eastern side of the valley, towards the base of the broad flattened ridge of Laurel hill, comprises a wild, barren country of sandy hills and swampy glades, offering nearly insuperable impediments to Geological explorations. Near the eastern base of Chesnut ridge, about a mile and a half south of the national road, on a tributary of of Sandy run, there exists a quantity of good iron ore. It has been extensively explored by Andrew Stewart Esq., who has lately erected a furnace for smelting it. A little north of the national road in the same range, ore is extensively dug, being transported across the the mountain, to be smelted in Huston's furnace, near Uniontown. Between the national road and the Youghiogeny, the country is generally covered with forest and is very rough and wild, becoming towards the river exceedingly broken and hilly. Seams of coal and layers of iron ore, are here found. The ore is used in two or three furnaces in the neighborhood of Laurel run on the south, and of Saltlick creek on the north of the Youghiogeny. Other furnaces formerly in operation here, and to the north towards Ligonier and Laughlinstown, are no longer in action. On a range of hills, situated about midway between the bases of Laurel hill and Chesnut ridge, north of Ligonier, a valuable seam of coal usually nearly seven feet in thickness, has been opened in many places, and may be extensively traced; its position in the strata, is evidently higher than the seams commonly met with, near the bottom of the series, which measure respectively about three, four and five feet. As it produces coal of a superior quality, the thinner beds, are in this neighborhood, almost wholly neglected. It follows nearly the summit of the ridge, which ranges along the centre of the valley from Ligonier to Fairfield, to within almost three miles of the Conemaugh. Beyond this point, the large bed is no longer to be met with, the denudation of the upper strata between this and the valley of the river, having left only the lowest portions of the coal series. A valuable iron ore, belonging to the lowest strata of the coal measures, occurs east of Fairfield, on the western slope of Laurel hill, and has long been worked at Ross furnace, in the neighborhood. A little below the thick upper coal

seam, which lies between Ligonier and Fairfield, there lies a very useful bed of limestone, varying in thickness from three to four and a half feet. It is much less impure, than that which generally occurs between the coal beds in this region, and therefore yields a better and whiter lime. Near Lockport and at other places along the deep valley of the Conemaugh, the lower seams of coal are exposed, and if an extensive demand for coal were ever to arise, they would offer great facilities for mining operations. Extending our explorations, northward along the middle of the valley, we find ourselves again above the lower coal seams, in the neighborhood of Armagh, but they rise to the surface and finally crop out and disappear, as we draw near to the base of either of the ridges, which bound the basin. This remark holds good as far north as the tributaries of Yellow and Two Lick creeks, the channels of which, lying in deeply denuded ravines, the lower coal seams are frequently exposed along their banks.

This brings us to the northern termination of Chesnut ridge, which grows very irregular and depressed near Yellow creek. North of the turnpike, between Ebensburg and Indiana, neither the ridge nor its anticlinal axis are any longer perceptible. No valuable beds of coal occur near the town of Indiana, which lies too high for the lower seams, which are exposed in the ravines of Two Lick and Yellow creeks, from four to six miles east and southeast of the town. On Yellow creek near the northwest foot of Chesnut ridge, in the slate above a neglected coal drift, there was found a deposit of Iron ore, which would justify more careful examination by digging, being only partially exposed in the bed of a little stream. About five miles northward from Indiana, on a branch of Crooked creek, we find a seam of coal, the position of which in the strata, is certainly higher than that of the seams on Yellow and Two Lick creeks. Its thickness is sometimes stated to be seven and a half feet, though it yields only about six and a half feet of coal, the seam being separated into two portions by a band of slate thirteen inches thick, the lower mass of coal being four feet, and the upper two and a half in thickness. Northward towards Mahoning creek, the country is high and rugged, the population more sparse, and the impediments to a minute exploration very considerable. Arriving at Mahoning creek, the seams of coal again appear adjacent to the stream. At Mr. Bell's, north of the Big Mahoning creek, and about a mile north of the Jefferson

county line, in a position nearly three hundred feet above the level of the stream, a partial excavation of a seam of coal has been made, in a bed which is possibly the same as that alluded to on Crooked creek. At this place, however, the dividing slate is three feet thick, the upper mass of coal being three feet in thickness, and the underlying one, buried at the time under water, by imperfect drainage of the mine, was stated to be at least four feet. Between twenty and thirty feet above this coal bed there exists a stratum of limestone, the thickness of which has not yet been ascertained. The lower seams in Mahoning creek are from three to five in thickness, and yield coal of good quality.

In the neighborhood of Punxatawney, there also occurs a seam of coal which has seven feet of thickness.

The details above presented, will serve to show a remarkable regularity, in the position of both the coal and the iron ores throughout indeed the whole broad belt of country embraced between the Allegheny mountain, and the Chesnut ridge, and from the southern line of the state to the counties of Clearfield and Jefferson. Of the coal, there would appear to be at least three seams of moderate dimensions occurring in the lower part of the series, and at a considerable elevation above these, a bed of considerable size and usually of superior quality. To know which of these we are likely to encounter in any given neighborhood, it is chiefly necessary to attend to the direction in which the rocks incline, and to the relative elevation of the place, compared with some one of the strata, adopted as a Geological basis. The more usual positions of the iron ore have been already referred to. It is easy to perceive that from the measurements already executed, and from others to be hereafter undertaken, with a view to exhibit as exactly as possible, the relative situation of the several seams of coal, beds of limestone, and the layers of iron ore, which expand widely under the surface of these basins, the explorations of individuals will be greatly facilitated. It is for the purpose of making the details, which I wish to offer in my final report upon these less known districts of our state as precise and ample as practible, that I propose to continue to some extent, the investigation of the districts above described, and to place hereafter in some of the wilderness portion of the region, northwest of the Allegheny mountains, a part of the corps supplied with a tent or tents, and with instruments for measuring and with tools for exposing the strata, to

the extent at least, which is necessary, to enable us to recognize and trace the mineral deposits.

It may be useful to those who are exploring some of the mountainous tracts, which lie within the enormous coal field, above deliniated, and serve to guard them against illusions, if I briefly describe the character and aspect of the three formations, which are situated next beneath the coal measures, and which therefore frequently occur in the same tracts of country with them. Next below the sandstones and shales immediately associated with the seams of coal, we have a formation comprising coarse white and yellowish grey sandstones, occasionally imbedding thin layers of dark carbonaceous shale, and usually containing in its uppermost portion, a heavy stratum of coarse white quartzose conglomerate, the pebbles of which are generally rounded. This last rock where it exists in the formation, is an admirable and well known guide to the position of the coal, the lowest seam of which will be found most commonly, though not invariably within one hundred feet perpendicularly above it. But in many districts, not only in the interior of the coal fields, but along the Alleghenv mountain, the formation is destitute of this distinguishing stratum, and in such places the knowledge of some other land mark, by which the explorer may at any spot, ascertain his position in reference to the rest of the rocks, and especially to the coal, becomes of the highest practical value. Such a land mark is to be found, at least throughout a very wide extent of country, on the southeastern border of the coal field, but particularly towards the southern side of the state, in the highly characteristic and easily recognized stratum of red shale, which constitutes formation XI, of our series. Fortunately this stratum is present in many situations, where the conglomerate, the distinctive bed of the next overlying formation is wholly wanting. The neighborhood of Farrandsville, on the West Branch of the Susquehanna, suggests itself as an instance. Here the coal is confined to the summits of the loftiest hills in the vicinity, within about one hundred and fifty feet of whose tops, we encounter, though much diminished in thickness, the well marked material of formation XI, the total depth of the stratum being only about twenty-four feet. But between its upper surface, and the bottom of the lowest of the coal seams, the distance is not more than eighty-two feet, and it is within this space that the whole of formation XII. as far as it developed in this neighborhood is comprised. Occurring as a fine grained white sandstone. and being entirely destitute of any layers

containing pebbles, it has been frequently confounded, not only here but elsewhere in the state, with the true coal measures that rest above it. The thick series of sandstones and shales, which compose formation X. and form the entire mass of these hills, down to the level of the Susquehanna, has been also considered as belonging to the proper coal bearing strata. This mistake, which has proved a very pernicious error, has arisen from overlooking the well traced line of separation, which nature has drawn between the strata, affording us an unerring guide, in the beds of the red shale formation. This red shale mass, formation XI. though a conspicuous and very thick stratum, where it encircles the mountain ridges, which enclose the anthracite coal measures, thins away to extremely diminished size, when we extend our observations as far northward as Lycoming county. From numerous measurements made in a former year, and presented in my last annual report, it exhibits perhaps more strikingly, than any other rock of our secondary series, a rapid abatement in thickness, as we pursue it further to the northwest. But while it augments to the southeast, it likewise expands, though very gradually, as we trace it southwestward, acquiring as it ranges in that direction, a new and highly valuable layer, consisting of a very thick band of pure limestone, inserted near the bottom of the mass of red shale. The increased thickness of the whole formation and the position of the included stratum of limestone, may be seen in the striking exhibition of the rocks, afforded by the Conemaugh and the cuttings of the Allegheny Portage rail-road, where the latter crosses the stream by an interesting viaduct. Still further to the south, the formation contains a bed of calcareous sandstone, and is considerably developed in the Little Allegheny, the Savage, the Great Allegheny, and the Negro mountains, also in Laurel hill and Chesnut ridge, (here erroneously called the Laurel hill.) This calcareous sandstone which in some places approaches closely to a limestone, is extensively employed as a road stone, for McAdamising the national road, and to a partial extent other turnpikes, which lie convenient to its outcrop. For this it is admirably adapted. In thickness it varies from thirty to sixty feet. Near the national road it is reddish in the lower layers, and of a light bluish grey in the upper, but as we trace it northward, the reddish bands disappear. In many places in the southern part of the state, this highly calcareous sandstone is overlaid by a limestone a few feet thick, which is an extension apparently of that above referred to, as seen on the Conemaugh. This limestone

is converted into lime, in considerable quantity, at Peck's and Ringer's, in Addisontownship in Somerset county, the lime being much prized, as it greatly exceeds in purity and whiteness, any which is procured from the limestone of the coal measures. Certain bands of this limestone and of the shale contiguous to it, are exceedingly fossiliferous, and as formation XI. to which the rock belongs, presents in scarcely any other district of the state, sufficiently distinct fossil remains, to enable us to institute a comparison between this and the other formations, as to the circumstances under which their strata were deposited, these characteristic relics, are invested with considerable scientific interest.

Having given a general description of formations XII. and XI. it remains for me to allude to the formation X. This stratum consists of a thick mass of white, grey, and buff colored sandstones, with interstratified beds of brown, dark bluish and olive colored slates, among which are occasional bands of dark carbonaceous slate, not unfrequently appealed to, as an evidence that the whole is a series of coal measures. This error, so prejudicial by inducing a search for coal in this formation, is apt to receive confirmation in the minds of those who study the mere analogies in the external aspects of the rocks, and neglect the more certain guide afforded by the relative positions of the several strata, inasmuch as they frequently find in some parts of the mass, the impressions of vegetation, or even thin sheets of an inferior species of coal of very limited extent and thickness, such as we often see among the true coal bearing slates and sandstones. The thickness of formation X. is very considerable, being usually several hundred feet. This circumstance in conjunction with the relative hardness of its strata, contrasted with formations XI. and VIII. which adjoin it, has caused it to resist the floods that scooped out the valleys, in the softer rocks, and to rise into bold and conspicuous ridges. In consequence of this character, the formation before us constitutes the true border of the great bituminous coal field; at least every where along its southeastern margin, capping the escarpment of the Allegheny mountain in almost every part of its range, from Maryland to the North Branch. From the same cause, it is exposed in all the axes of elevation, which sub-divide the great coal field, in the southern part of the state. Thus it occupies the broad summit of the Negro mountain, near the Maryland line, and forms the top, and no incon-

siderable portion of the sides of both the Laurel hill and Chesnut ridge, throughout nearly their entire length. Where these ridges decline towards their extremities, formation X. becomes buried under formation XI and formation XII, which there fold over their summits. Where those mountains retain their full height, the two latter strata usually rest upon their flanks. Formation XI, usually containing in these situations valuable deposites of iron ore, at present in much request at the neighboring furnaces, this structure of the ridges, just mentioned, imparts much practical importance to their Geology. The systematic investigation of that valuable formation already commenced, will be therefore pursued with as much minuteness, as the organization of the Geological survey will authorize.

SECTION III.

OF THE OPERATIONS OF THE SURVEY IN THE FIFTH DISTRICT, EMBRACING THE COUNTRY WEST OF CHESNUT RIDGE, AND THE ALLEGHENY RIVER.

Having in the foregoing descriptions, presented as consisely as practicable, a portion of the observations, made in the exploration of the country between the base of the Allegheny mountain, and the summit of Chesnut ridge, and having reserved for my final report the chief body of the more minute and local details, together with the results of instrumental measurements, all of which require to be ultimately accompanied by numerous drawings and a Geological map of the region, before they can be adequately understood, or their practicable importance fully appreciated ; I shall in the next place offer a similar general account of the Geological structure and resources of those sections of the State, which we have explored, lying west of Chesnut ridge, and also between the Allegheny river and the Ohio state line.

Considering the anticlinal axis of Chesnut ridge, and a range of elevated strata nearly in its northwest prolongation, as the true boundary of the main or northeastern basin of the whole bituminous coal field of the state, and the low chain of hills capped by the sandstone and conglomerate of formation XII, passing through Mercer, Crawford and Warren counties, as its other margin, (the minor undulations within these limits requiring to be neglected, in a comprehensive view,) we shall find proofs of a remarable degree of uniformity in the strata and their contents over this extensive region, im-

plying a singularly extensive range, in many of the principal beds of the formation. The influence of this feature in the Geology, on the early and full developement of the economical resources of the western and northwestern counties, it would be difficult to overrate, for the data derived in any one neighborhood from judiciously planned and conducted measurements and observations, become of exceedingly wide application, in leading us to a knowledge of the state of things elsewhere; and if these measurements can be made sufficiently numerous, an amount of accurate knowledge will be furnished, capable in such a region of imparting a high degree of certainty and success, to the undertakings of miners and others, who aim at unfolding its mineral wealth, to supply the wants, or add to the comforts of the community.

In presenting a brief description of this western coal basin, I shall commence on the side next the anticlinal axis of Chesnut ridge, and make mention of the various strata in the ascending order, which leads us to the beds of the coal formation, as they cap the surface in the interior of Greene county, and therefore to the uppermost of that vast series of deposites, which I have termed the lower secondary formations of Pennsylvania.

The same order will be observed in speaking of the country, included between the Allegheny river and the Ohio state line.

SANDSTONES AND SHALES OF FORMATION X.

The lowest rock which presents itself to our notice in obedience to this plan, is the thick sandstone, formation X, which bounds the basin, ranging in a belt along the summit of Chesnut ridge, where it shows itself in many places, folding with opposite but gentle dips, over the anticlinal axis of that mountain. Where the national road crosses this ridge, we find it in the form of a hard, white, finegrained sandstone, with a somewhat glazed surface, often thin-bedded in its structure, and much traversed by fissures and irregular joints. It is of considerable thickness, and dips to the west twenty-five degress north, at an angle of twenty-five degrees. Beneath it there is a thick mass of alternating beds of slaty sandstone, and shale or slate, the former in layers of from one to thirty feet in thickness, being hard, fine grained and of a grey color; the latter black and yellow, and sometimes of a feruginous brown color, irregularly laminated, and readily crumbling when exposed to the atmosphere.

On the Loyalhanna, similar sandstones are met with, while on the Conemaugh, above Blairsville, the observer will notice in the same relative situation, a number of alternations of white and grey sandstones, separated by shales.

FOSILIFEROUS LIMESTONE OF FORMATION XI.

This rock interposed between the previous sandstones and the over lying red shale to which it belongs, is the best marked, most peculiar and interesting rock of the series composing this mountain range. It can be traced from the Conemaugh to the southern state line, and is found dipping both east and west, or on both sides of the anticlinal axis. It is a siliceous limestone, or a limestone containing a small quantity of pure and well rounded grains of sand, is of fine texture, and of a light blue color, though sometimes its tint is yellowish green. On the national road it is found on the first ridge, and also on the main mountain, in the former case, dipping west fifteen degrees north, at an angle of twenty-five degrees. It lies in layers of from one to ten feet or more in thickness, separated by bands of a calcareous shale. The upper part is remarkably full of fossils, as is also the intervening shale. On the Susquehanna, there are two beds or layers exposed, separated by a thick bed of red and yellow shale, containing a few bands of limestone. The lower bed is a most singular rock, of a light blue color, very hard, and breaks with a semi-conchoidal fracture. It dips nearly due westward, at an angle of ten degrees. Occasionally the yellow color predominates, giving the rock the exact appearance of some varieties of serpentine. When exposed to the water it decomposes, the calcareous matter being washed away, leaving a porous and siliceous crust of an inch or two in thickness, which will not effervesce. This bed measures thirty feet in thickness, being a nearly solid rock, without a seam, the upper one is of a darker color, harder and more fosiliferous, and four feet in thickness. At other points on Chesnut ridge, this rock is met with having a considerable thickness, but no opportunity was there afforded for accurately measuring it.

On the Conemaugh, this stratum is exposed on both sides of the axis, dipping both east and west; it is accompanied with shale of a bright purple color, and appears to be very thick. There is reason to believe that small quantities of lead and zinc ore may be detected, in the lower beds of this deposit, particularly on Chesnut ridge, where it seems to have reached its greatest developement. Regarding it

and the accompanying red and variegated shales, as belonging to formation XI, underlying the western coal measures, the whole group, will be seen to be much thicker here than further northeastward, in the slate, especially along the Allegheny mountain, while its features are more characteristic. The dark blue bed of limestone, which is full of fossils usually affords an excellent lime.

RED SHALE OF FORMATION XI.

Overlying the limestone and surmounted in its turn by the sandstone and conglomerate beds of formation XII, occur the beds of variegated shale belonging to formation XI, red, black and yellow, which are much exposed in various places by diggings made in search of ore. At Cool spring furnace, there are found two thin veins of coal, about one foot thick, beneath the conglomerate. The first dips at an angle of thirty-two degrees, and is imbedded in the shale. Beneath it is a bed of blue ore, a proto-carbonate of iron in three layers, composed of irregular nodules from eight to fifteen inches in diameter. It is not probable that any large deposites of coal will be found in this stratum of shale, inasmuch as the conglomerate beds of formation XII, appears with only few exceptions, to underlie the lowermost workable coal bed in all the coal basins of our state—but as a depository of ore it merits close investigation. This stratum is well exposed on the Loyalhanna near Youngstown, and also on the Conemaugh above Blairsville. At the former place its beds are red and blue, well laminated and compact, and dip at an angle of ten degrees, nearly due west. The thickness here from approximate measurements, that were made must be nearly ninety feet. At the latter place it is much thinner, and of a prevaling purple or red color.

SANDSTONE AND CONGLOMERATE OF FORMATION XII.

Running parallel with the preceding and resting upon it, we find on the western flank of the Chesnut ridge, an important and conspicuous stratum, forming the true margin of all our coal basins. Here it dips towards the west, under the coal measures at the base of the Chesnut ridge. It is a true conglomerate, particularly in the lower part. The pebbles are of white quartz, sometimes disposed in bands, but at other times forming a very coarse conglomerate, excessively hard, which has a glazed appearance. On the Chesnut ridge, opposite to Uniontown, it is well exposed, its outcrop forming a ledge a-

bout thirty feet in height. It dips at an angle of thirty-five degrees, in a direction west twenty-five degrees north, It must be recollected that only the lower part of this stratum is a true conglomerate, and as we follow it north, this portion, of the stratum, seems to be less perfectly developed. On the Loyalhanna, where the formation is easily recognized by its position in regard to the fosiliferous limestone, it shows little of the conglomerate character being a coarse white sandstone. At Mount Pleasant it was not seen in place. Pursuing it towards the southwest, it appears to increase in thickness, until we cross the Virginia line.

FORMATION XIII—COAL MEASURES.

I. Colored shales with coal six feet thick and iron ore.

At the bottom of the true coal measures, the first distinctly marked sub-division of the strata, is a thick bed of shale. It is generally soft and usually highly colored, being red, black, and yellow in various shales. It contains both iron ore and coal. At Cool Spring furnace, ore of good quality has been obtained from it, and Etna furnace, one mile east of Connelsville, is also supplied with ore from the same stratum, which has been worked for twenty years, and gives every indication of containing an almost inexhaustible supply.

At the former place a seam of coal has been opened at several points, and is estimated to be about six feet in thickness. It appears to be of good quality, and lies in the lower part of this shale stratum. It is accompanied by bands of ore. Near Youngmanstown two and a half miles north of the Loyalhanna, a seam of coal has been opened on the property of W. Johnston, Esq., which from several features about it, is probably the same with the one above described; if not it occupies very nearly the same position. It is near the summit of the first or westernmost ridge of the mountain, is six feet thick, and is probably accompanied by ore, although no excavations have been made for that mineral.

This stratum from its well marked position and valuable contents, is worthy of a detailed examination throughout its whole extent, and in the future operations of the survey, will receive its due proportion of research.

No. II. White sandstone.

Along the summit of the western ridge of the mountain, called the

Chesnut ridge, there can be traced a thick stratum of sandstone, dipping with a regular inclination to west twenty-five degrees north. The outcrop of this rock forms in many places, a steep ledge thirty feet in height. It is a solid, and generally fine-grained sandstone, admits of being readily dressed, and splits into well shaped prismatic blocks. Sometimes it crumbles on exposure into a beautiful white sand. The general color of the stratum is yellowish white; it is also seen brown, red, or with spots of a peculiar rosy tinge. The lines indicating the laminæ of deposition, are generally very evident, and the lower portions are sometimes a conglomerate in thin and irregular bands. These bands are composed of white quartz pebbles of small size. This stratum apart from its thickness and extent, is important, as pointing to the principal position of the iron ore, so abundantly distributed along this ridge and which lies chiefly beneath it, and above the main conglomerate or formation XII. It is well exposed on Chesnut ridge, opposite to Uniontown, also at other points in the same chain, as at the gap of the Youghiogheny and opposite Mount-Pleasant, and on the Loyalhanna, where it abounds in impressions of lepidodendra, sigillaria, and other plants common in the coal measures.

No. III. Shale—Coal three feet thick—Iron ore.

Over-lying the white sandstone, there rests a heavy bed of shale of the variegated appearance, quite usual in the lower shales of this section of the basin, whose thickness, though obviously considerable, was not determined, through want of a favorable place for making the measurement. This shale like the other similar beds of the mountain, contains coal and ore, but the principal imbedding stratum of the latter mineral, is the shale, (No. I,) already mentioned, between the white sandstone ledge and the conglomerate. At Cool Spring furnace, three and a half miles northeast of Uniontown, a coal seam about three feet thick shews itself in this stratum. This has not been mined, but iron ore of good quality has been obtained from the yellow and black shale above it.

No. IV. Sandstone.

This stratum in its upper part consists of layers of sandstone separated by shale, which is yellow and black, very soft and full of vegetable impressions. The layers of sandstone are hard and fine-

grained, usually from three to six inches in thickness, gradually become more numerous and closer together, as we pass towards the bottom of the mass, until a compact rock presents itself. These thin beds are often broken and contorted in a singular manner.

No. V. Shale.

Ascending we pass from the upper layers of the preceding stratum, by a gradual transition into a bed of shale, resembling the shales of the open country, west of the base of the mountain. It is soft and imperfectly laminated, and like the other shales described, of several colors, being brown, black and yellow. Thickness, one hundred feet.

No. VI. Sandstone, 100 feet thick.

Surmounting the shale just mentioned, in the part of the mountain that lies to the southwest of the Chesnut ridge, (called Laurel hill on the map,) and which is here much elevated, and contains the strata better developed than the northeastern portion of the ridge, we find a sandstone of some thickness. The rock in the upper part is coarse and brown, that in the lower part occurs in layers very hard and tolerably fine-grained. The thickness of this rock cannot be less than two hundred feet. It was identified only on the southwestern section of the Chesnut ridge, where it is inclined at an angle of twenty degrees, dipping nearly due west.

NO. VII. SHALE WITH LAYERS OF SANDSTONE—COAL.

The next sub-division of the series is a bed of shale, with layers of sandstone. It appears to be of considerable thickness. These layers, from one to four inches in thickness, consist of a yellow fine-grained sandstone, The shale is yellow and black, constituting the principal part of the bed as far as hitherto determined. At several points along the base of the mountain, there are decided indications of the existence of beds of coal in this stratum, indeed in a few places these have been opened. They are unquestionably seams that are situated below the Pittsburg series, rising, and cropping out along this line. This part of the country is still so covered with forest, and the excavations are so limited, that it is impossible to see the accompanying strata, and consequently to determine

the precise situation of these seams, but there is at present, good reason to believe, that two of them are contained in this bed of shale and sandstone.

On the farm of Mr. Woods in Union township, Fayette county, at the base of the mountain, a coal seam is found dipping westward at an angle of eighteen degrees, in apparently the above mentioned sandstone. It is about four feet thick, but the accompanying strata are not discernable, except where the following section is exposed.

Soil,	2 feet,
Shale, yellow,	4 "
Coal, impure,	1 "
Shale, blue and friable,	2 "
Coal compact,	4 "

About one hundred yards west of this exposure, on the same ridge, we encounter evidences of another coal seam, which has not yet been opened. About one mile south of this place, a drift has been made into a bed of coal, which we have good grounds for believing, is the same as the one here mentioned. This place is just at the foot of the mountain, and on the east side of a low ridge, which shows shale and slaty sandstone dipping west, and overlying the coal. There are also indications of another vein, observing the same distance above the first, as exists between the small seam noticed in the section and its companion.

About one fourth of a mile west, the *Pittsburg seam* presents itself, exhibiting a noble bed of coal, nine feet in thickness.

In Derry township, Westmoreland county, about three miles north of Youngstown, a seam of coal has been opened on the farm of —— Knoll, presenting features which give us reason to believe it to be a continuation of the bed above referred to, as belonging to the present sub-division of the strata. It can be traced for some distance on a low ridge, about one mile from the mountain and is worked in several drifts. It measures five feet in thickness, yields coal of good quality, and exhibits just over it, layers of shale and slaty sandstone, though imperfectly exposed.

About six miles west of Mount Pleasant, in Westmoreland county, there are numerous saltworks on the Big Sewickly creek, which are supplied with fuel from a coal seam, whose presence in this position can only be accounted for, by supposing it to be one of the inferior beds thrown up in the line of an anticlinal axis, which passes

in this vicinity. This bed is five feet thick, with brown shale above and below it, and is worked for the use of the salt-wells and steam mills adjacent. Salt water has been found here at the depth of one hundred and thirty feet. Both to the east and the west, a thicker bed, being the same with the main Pittsburg seam, is extensively mined.

The coal seam which for the sake of precision, I denominate the Pittsburg seam, is found about three miles west of the creek, and two and a half miles east of it.

At Middletown, in Fayette county, near the line of the anticlinal axis before mentioned, there is exposed a bed of coal three feet in thickness, at an elevation of about thirty feet above the Red Stone creek. Overlying it, are brown and black shales and a slaty sandstone. Judging from a hasty examination, this bed must lie beneath the Pittsburg strata, and probably be identical with the one above described.

No. VIII, Sandstone.

On the western slope of the hills, which we first meet in the ascent of the Chesnut ridge, and which form the first bench or terrace on the flank of the mountain, the only rock seen in place, is a slaty sandstone of a brown colour. It is hard and coarse grained, occurs in layers from six to eight inches thick, which increase in number and thickness towards the lower part of the stratum. It is very indistinctly exposed, being covered with soil, vegetation and the debris, from the more elevated rocks of the mountain. This stratum was principally noticed at Uniontown, but in other situations, the rock immediately at the base of the mountain, is so similar to it in many respects, that it is not practicable to distinguish them.

Our principal object in the explorations during the past season, being to ascertain the nature and contents of the strata, which compose the valley of the Monongahela, as far eastward as the base of Chesnut ridge, our examinations of the mountain, were necessarily very general. From a deficiency of time, which another season will remedy; we were only enabled to investigate minutely, a few points, namely: opposite Uniontown, on the national road, at the gap of the Youghiogheny, opposite Mount Pleasant, on the Loyalhanna, near Youngmanstown, and on the Conemaugh, above Blairsville.

Along the western base of the ridge, the Pittsburg series rises to

the surface, the coal No. seen in place on the Allegheny river, being in many places from half a mile to two miles from the mountain. It is by no means easy, however, to distinguish the other strata associated with it. From the Youghiogheny to the state line in a southwestern direction, there may be seen a depression or narrow valley running along the foot of the mountain. Immediately west of this little basin or valley there rises, displaying along its eastern slope one or two low steps or terraces, a long anticlinal elevation of considerable breadth but no great height. It can be traced north of the Youghiogheny, but in that direction gradually becomes less distinct. This valley was most probably formed originally by the scooping action of the retreating waters, as they precipitated themselves down the western flank of the mountain, rushing with enormous momentum over the soft shales that so largely compose this lower stratum of the coal measures. Its existenee, interesting as a subject for geological speculation, is rendered additionally important by the impediments it offers in the present state of the surface of the country, to our ascertaining all the strata which lie immediately beneath the great Pittsburg coal seam, and which necessarily reach the surface along this belt of country, at the base of the mountain. The foregoing account of this lower part of the series, is however, tolerably complete, and I entertain a confident hope that the explorations of the next season in the same district will leave nothing of practical or scientific interest connected with these rocks undetermined. By employing the more ample data which we are collecting along the western base of Chesnut ridge, to interpret the stratification of the far less distinctly developed basin that lies along the eastern base of the same mountain, we shall be able to clear up much existing obscurity in our knowledge and add materially to the usefulness of future explorations in that quarter.

PITTSBURG SERIES.

COMMENCING AT THE LEVEL OF THE OHIO RIVER AT PITTSBURG, AND EMBRACING IN THE ASCENDING ORDER ALL THE STRATA, TO THE UPPERMOST IN THE SERIES AS FAR AS THEY HAVE YET BEEN IDENTIFIED.

No. I, Red and Blue Calcareous Shale.

At Pittsburg we find at the base of the hills which overlook the city, a bed of variegated calcareous shale, of a peculiar mottled appearance, its lower portion reaching down nearly, if not quite to

the brink of the Ohio river. This shale we make the first in our enumeration of the strata, which compose the valley of the Monongahela. At the mouth of Sawmill run, and at several other places in that vicinity, a bed of sandstone is seen, just rising above the water level, probably the upper part of a thick deposite, but as it has not yet been observed in other places, and no opportunity for its further examination has been thus far afforded, it is omitted for the present and considered as belonging to the strata beneath the present series. The shale above mentioned is a bed of considerable thickness; it consists of two varieties, one blue and the other a bright purple or red, irregularly intermixed in spots, blotches and bands. The blue variety lies sometimes in continuous layers. It is soft and calcareous, sometimes without any regular cleavage, and exists throughout as a rather homogeneous mass, very friable and easily crumbled by the weather. Dispersed through it, are numerous calcareo-ferruginous concretions, lying in irregular layers, and occasionally so abundant as to constitute a considerable part of the whole bed. They are of all sizes, more or less ferruginous and excessively hard.—Some minute fossils have been detected in this stratum, but it is generally not fossiliferous. The quantity of calcareous matter diffused through the shale, is such in fact, as to warrant our considering it an impure *marl*. From Pittsburg it may be traced along the western bank of the Allegheny river to some distance above Sharpsburg, rising as it extends northward in conformity with the general slight southwestern dip of the strata. On Thompson's run, a branch of Turtle creek, fourteen miles east of Pittsburg, it is met with at nearly the same elevation as at that city, forming the base of the hills. Being at the bottom of the series as hereabouts exposed, it is only within confined limits, restricted to the lowest parts of the central district of the coal basin, that this stratum is exhibited. Back from the rivers it conceals itself beneath the hills, and must finally crop out upon the surface if it does not thin away towards both the southeastern and northern sides of the basin, where we hope that extended researches will identify it, and trace its position.

No. II, Coal.

Resting on the above, is a thin seam of coal, varying in its thickness from six to eighteen inches, and of good quality, and though a narrow band ranging over a considerable, perhaps even an extensive

area of country. It is hard, black, brilliant. It is well displayed in contact with the preceding stratum at the base of the hills in the immediate vicinity of Pittsburg, and was detected by us also in Indiana township, Allegheny county, and in Franklin township, Westmoreland county. It probably crops out towards the north and east, with the other members of the series, but its thinness renders it difficult to trace it by any indications of its own on the surface. One foot is about its average thickness.

No. III, Limestone.

This is the highest fossiliferous limestone met with, in the Monongahela valley. It is a dark grey or black limestone, when first exposed is extremely hard, effervesces freely, and when treated with an acid, is remarkable for the abundance, though not the variety of the fossils diffused through it. These are principally bivalves species of productu, leptena, terebratula, &c. Joints of encrini, are also very abundant, from one-sixteenth to one-half an inch in diameter, the column being composed of chrystallized carbonate of lime, which has a handsome appearance when freshly broken. Another very abundant and characteristic fossil is a species of orthecera, from one-half to two inches in size, often abundant on the surface of the rock. Ammonites have also been found in it. When exposed near the base of the hill, this stratum forms a shelf above the small coal bed, it is of a brownish grey color, and outward slaty structure. If judiciously selected it will make a good lime, and has been used for the purpose on the Mechanics' and Farmer's turnpike at Pittsburg. In company with the preceding strata, it rises to the north along the margin of the Allegheny river. It has been detected by us in Indiana, Wilkins and Versailles townships, Allegheny county, and in Washington and Unity townships, Westmoreland county, and on the Kiskiminitas, below Saltsburg. Thickness about two feet.

No. IV, Olive Slate and Buff colored Shale.

The next stratum ascending, is a heavy deposite, consisting of shale, passing into slate, with sandstone layers. The lower portion is a soft shale of a drab or yellowish color, regularly laminated, and decomposing into a stiff clay. Nodules or concretions of compact, fine grained and tolerable pure limestone are dispersed through it. It passes into a heavy slate, of blue, yellow and black color.

It is slightly micaceous, contains a good deal of sand, and splits into plates, somewhat resembling roofing slate. Upon this, in some places, there is a thick bed of slaty sandstone, passing gradually into a smooth slate. The sandstone layers are sometimes very compact and heavy, at others separated by bands of shale. The dark colored portions of the stratum, are generally fine grained, have a ready clearage, and contain impressions of plants. Plates may be obtained two feet square, beautifully marked with these remains of an ancient vegetation. These are not found in the hard siliceous upper layers. The whole mass may sometimes be observed, divided in a vertical direction by joints, which seperate it into prismatic blocks and impart a picturesque appearance to the exposed portions. Layers of calcareo-ferruginous concretions are found running parallel to the clearage. They are generally round and rough or knotty on the surface and from two to four inches in diameter.

The upper part of this bed, immediately beneath the overlying stratum, differs frequently in appearance from the rest. It is much softer, red or yellow in color, and slightly ferruginous. The hard siliceous portions afford an abundant supply of good flagstones.—The dark black bands have been mistaken for the soft shale accompanying the coal.

This member of the series may be traced generally along the water courses throughout Allegheny county, and is exposed in Unity and Franklin townships, Westmoreland county, and Connelsville township, Fayette county.

Thickness by estimation—one hundred feet.

No. V, Grey Sandstone. Building Stone.

Upon the above, there rests a valuable and important deposit of sandstone. The lower portion is very solid and compact, affording an excellent material for building and differing from the upper, which is generally too slaty, and broken to be used for this purpose. The prevailing color is a light grey, with a yellowish tinge; in other places it is brown and brownish green. It varies in composition as much as in color, but generally admits of being easily dressed, and of being readily split into prismatic blocks. Some portions are remarkably micaceous, in others the mica is entirely wanting. Occasionally, it is not fit for masonry, being too friable, and crumbling too freely on exposure to the atmosphere, in consequence, chiefly, of its

containing in these cases, a considerable proportion of clay. In this rock, the lines of deposition are very manifest, forming beautiful curves and accurately representing the eddying currents, by which the fine sand was originally deposited. These are most evident, where a brown layer interposes itself in the lighter colored rock.—Imbedded in the lower parts of the mass, are great quantities of pebbles, which differ in color and composition from the material of the surrounding sandstone; they consist generally, of a drab or a bluish colored clay of a fine texture, and contain minute specks of mica; they are from one to fifteen inches in diameter, but always rounded, and apparently water worn. The question of their origin, suggests some interesting enquiries, but I shall for the present waive all matters of mere hypothesis.

The lower part of the stratum contains also thin seams of vegetable remains. These fill the joinings of the layers, and are composed of black carbonized matter, which in some instances assumes the condition of a pure coal. They are slaty, friable and emit a bituminous odour, when freshly broken. These impressions are generally so interlaced and compacted together, that it is difficult to distinguish their forms; now and then however, distinct figures are traceable from six to eight inches broad, and also curved stems of considerable thickness.

In many situations, this rock is soft, crumbly and granular, consisting of rounded grains of sand, of a dark green and sometimes a brown color, passing into a ferruginous reddish tint. This change of color depends upon the quantity of iron present in the rock, and the stage of decomposition to which it has arrived. The grains are of pure white quartz, evidently water-worn and united by a calcareous cement, particularly in the green and brown varieties. In the former, some minute fossil univalve shells have been detected.

This rock is sometimes met with, in a state of complete decomposition in the form of a coarse sand. Certain layers are yellow, others bright red, with intervening layers of grey sandstone, which by their containing but little iron, have resisted decomposition. In these cases, the thin flakes of the vegetable remains, have been replaced by layers of black clay and sand. The rock in this state is too friable to admit of being transported. The upper part of the main stratum into which the preceding passes, is generally very schistose, with irregular laminations, and presents a broken, shattered

appearance. It is sometimes very full of nodules, which are chiefly concretions of an impure iron ore. This stratum affords an abundant supply of building stone to the city of Pittsburg. The sandstone employed in the construction of the New court-house, the Western Penitentiary and other public buildings, and also some private edifices, belongs to this member of the series. It is quarried in many places on the Monongahela, along whose banks it can readily be traced, until it sinks below the water level of the country, along with the other strata situated below the Pittsburg coal.—Medium thickness seventy feet.

No. VI, Shale.

This is a bed of red and marly shale, internally blue and mottled, resting on the schistose part of the preceding stratum, and forming in the hill sides a well defined belt of a bright red or purple color.—It is in general, imperfectly laminated, slightly calcareous and contains traces of fossil shells. It is not exposed on the hills immediately around Pittsburg, but may be observed on the level, or slightly undulating flat upon which East Liberty is situated. It extends widely through Allegheny county. The thickness averages twelve feet.

No. VII, Shale and Slaty Sandstone.

The next in order, is a thin and inconspicuous bed, yet sufficiently different from the accompanying strata to claim for it a separate recognition. It consists of blue or yellowish green slate, marked with ferruginous discolorations, and contains layers of sandstone.—When these predominate it is a course slaty sandstone. Ten feet.

No. VIII, Limestone.

This is the first or lowest of the non-fossiliferous beds of limestone beneath the Pittsburg coal seam. It is a well defined stratum consisting of a hard, yellowish or buff colored limestone, jointed into square blocks. It effervesces freely, gives out an argillaceous odour and is marked with transparent specks of crystallized carbonate of lime. It probably contains too much oxide of iron and argillaceous matter to yield a good lime. For weight and hardness it is quite remarkable. Although frequently exposed along the hill sides it is

not easy to trace this stratum, as it is very apt to be covered up by the matter from the overlying shales. Thickness three feet.

No. IX, Red and Blue Shale.

Reposing in immediate contact with the preceeding, we observe a bed of red and blue shales, distinguished by its want of tenacity, its bright colors and smooth cleavage. The red and blue portions are irregularly intermixed. This is one of the colored shales which give the red and variegated appearance to the lower part of this series and may be met with on the sides of the hills and ravines, throughout Allegheny and the northern part of Westmoreland counties. Around East Liberty this and the next stratum are found on the surface of the remarkable flat on which that suburb is situated, in many places decomposed and forming a red soil. Thickness four feet.

No. X, Buff Colored Shale.

Along the escarpment of the hills where the strata have been laid bare by slides or artificial excavations, we meet with a smooth face of compact and well laminated shale of a light yellow and buff color. This shale so greatly resembles in appearance some of the other beds that it can only be identified by its relative position to the accompanying strata. The surface is frequently white from infiltrations of carbonate of lime, and in other places is tinged brown with ferruginous stains. Thickness eighteen feet.

No. XI, Yellow and Purple Shale.

We have next a bed of variegated shale extending to the bottom of the next limestone. The lower part is frequently of a dark purple color, and is very soft and not well laminated. The prevailing color is yellow. It is frequently exposed on the sides of the runs and water courses. Calcareous nodules are scattered through it, sometimes constituting the largest portion of the statum. Thickness ten feet.

No. XII, Limestone.

Upon the preceding, is a thin bed of limestone, resembling No. VIII in appearance and composition. Blocks of it are frequently scattered along the base of the hills, having fallen down from the

washing away of the underlying bed of shale. Thickness two feet.

No. XIII, Red and Yellow Shale.

The next stratum is a bed of red and yellow shale. It varies much in composition but preserves its variegated character. It is soft and friable and contains a few calcareous nodules. Thickness twelve feet.

No. XIV, Limestone.

Over this rests a conspicuous and widely expanded bed of limestone of moderate thickness; owing to the presence of the oxide of iron: it is yellow on the surface though internally its color is dark blue. It breaks off in square or oblong blocks, which are hard and heavy. Portions of it might, perhaps, receive a good polish and experiments to ascertain this point will be made. By the decomposition of the underlying shales, it is often found tumbled down at the base of the high hills which enclose the Monongahela and Youghiogheny rivers, along whose shores its fragments are frequently abundant. Thickness from three to five feet.

No. XV, Shale and Sandstone.

Surmounting the last limestone, there occurs a thick and important deposite of shale and sandstone somewhat variable as to its composition, which extends up to the next bed of limestone or that which underlies the main Pittsburg coal seam. It may, in almost all cases be seen where the coal itself is exposed, generally in the character of a grey slate, well laminated with interspersed sandstone layers, varying from a few inches to several feet in thickness, and separated by soft bands of shale. The upper part of this stratum adjacent to the limestone is frequently very soft and friable, abounding in calcareous nodules, irregularly dispersed throughout the mass. Occasionally, but not very often, the sandstone layers increase in number and thickness, with a corresponding diminution of the shales, giving rise to a sandstone sufficiently compact to be employed in building. It is quarried for this purpose in the vicinity of Pittsburg, though more usually its principal useful application is in supplying much excellent flagstone, which it readily affords of large size and very smooth surface. This stratum extends through the valley of the Monongahela from the foot of Chesnut ridge to the western boundary

of the state, obeying the general inclination of the accompanying strata, and exposed in corresponding situations. The sandstone layers very frequently exhibit "ripple marks," disposed with great regularity, showing that the rock was deposited from a rather gentle current and probably in a shallow sea. Impressions of arundinaceous plants are not uncommon. Thickness by estimation thirty feet.

No. XVI, Limestone.

Resting on the above, and immediately underlying the Pittsburg coal seam, is a bed of limestone of characteristic appearance and remarkable for the regularity with which it accompanies the coal. It consists of blue and black limestone in layers from six to ten in number, separated by shale. One of these layers is generally found immediately under the coal seam, succeeded by the principal body of the shale, beneath which are the remaining layers of limestone in a close and continuous stratum. These layers are from one to two and a half feet in thickness and vary in their color, which is generally dark blue, though at other times it is a deep black, in which case the rock is ferruginous, and gives out a bituminous odour. When there is a deficiency of calcareous matter, the upper layer adjacent to the coal seam is wanting, and its place is supplied by a layer of excessively hard calcareous nodules called "nigger heads" by the miners, and which are imbedded in the usually intervening shale. In the northern part of the district this shale is of a light yellow and brown color, is slightly calcareous and contains some ferruginous concretions. In the eastern part of the district, along the base of Chesnut ridge, it is distinguished as one principal depository of the valuable iron ore, for which that belt of country is deservedly noted. Like many of the other strata of the series it appears to augment in thickness and particularly in its ferruginous character as we advance south and southeast. It is chiefly along the eastern outcrop of the Pittsburg coal seam, that we are to look for valuable deposits of *iron ore*. Thus in George and Union townships, in Fayette county, large quantities of admirable ore are obtained from this stratum.

It underlies the coal which is here of increased thickness. The ore is of the variety properly called an argillaceous protocarbonate of iron, distributed in layers throughout the shales. There are three of these layers in close proximity in many places; the first, called the blue stone is about two feet below the coal, and separated from the

next, the masses of which are smaller in size, by clay or crumbling shale from one to two feet in thickness. Under this is the third layer or bed, of still smaller nodules, separated from the former by two feet of shale. Ore has been found in this stratum in various neighborhoods.

Instead of the black and crumbling shale dividing the lower layers of limestone, we sometimes witness a layer of coal one foot thick. This is the case at Brownsville and Connellsville. Its true character and composition may be ascertained from a comparison of sections taken near Pittsburg, Canonsburg, Williamsport, Limetown, M'Keesport, Elizabethtown, Brownsville, Connellsville, Blairsville, and other points throughout the district explored. Average thickness of the whole stratum twenty-five feet.

No. XVII, Coal. Pittsburg Seam.

Resting on the great limestone bed, we find the important coal seam, from which the city of Pittsburg and its environs are supplied with this indispensible mineral, and which may therefore, by way of distinction, be entitled the Pittsburg seam. It is probably the most important and extensively accessible seam of coal in our western coal measures. The examinations of the season have shown that it spreads uninterruptedly over the whole valley of the Monongahela, from the base of the Chesnut ridge to the western boundary of the state, if not to the Ohio river. The critical investigation of this bed and its accompanying ores, is highly interesting, and leads to some curious and striking geological inferences. The uniform disposition of vegetable matter over so extensive a tract of ocean, is in itself a geological fact, richly worthy of consideration, by any intelligent mind, while the regularity with which it maintains its characteristic features, is not less remarkable, or less likely to inspire us with curiosity to know more of the mighty operations of nature, during the earlier conditions of the earth's ever changing surface.

It consists of three parts, first the main breast of coal, and above this a layer of clay, and over this again a bed of coal, forming the roof. The former of these rests upon the limestone, from which it is separated generally by a few inches of blue clay or decomposed shale. It is from five and a half to eight feet in thickness, affording coal of the purest and best kind. In the neighborhood of

Pittsburg, the lower part of this mass for about one foot in depth, abounds in thin seams of pyritous shale, and is hence rejected by the miners. Above this part of the seam, there is the stratum of blue or black clay-shale, dividing it from the coal roof. It is hard and compact when first dug out, but on exposure to the atmosphere crumbles down into a soft clay. It is generally free from gritty particles and with a similar layer in the coal next the roof, it has been advantageously used in the manufacture of fine bricks. Above it is the roof coal, consisting of a bed of coal with shale intermixed in numerous thin layers. Towards the bottom this is a band of true coal from one to two feet thick; the higher layers are generally thin. The coal in this part of the seam, is in itself of good quality, but the expense of separating it from the accompanying slate is generally too great to justify the attempt. Hence the miners along the Monongahela, content themselves with extracting the lower division, leaving the remainder to form the roof of their drifts. In Allegheny county the main breast varies from five to six feet in thickness, but as we ascend the Monongahela and approach near the Chesnut ridge, it enlarges much, yielding in some places from eight to nine and a half feet of pure and compact coal. The quantity of pyrites in the clay and shale accompanying the coal, is very considerable, these layers readily crumble, and when exposed to the atmosphere are generally covered with *copperas*, produced by the chemical action upon the sulphuret of iron. These natural incrustations of copperas are very common throughout the district. In many instances, the coal of the roof has been precipitated by a slipping of the hill side, upon the lower part of the seam, in which case the latter has often taken fire from the heat evolved by the chemical decomposition just mentioned. This has occurred, particularly at the mouth of the Redstone creek, in Fayette county, where the overlying shale, has been baked and reddened by the combustion. The shale and clay of the upper part of the seam, abound in casts and impressions of plants, many of which are very beautiful.

In tracing this seam of coal, it was an object from the commencement, to ascertain the dip and range of so important a deposit, but we were soon made aware, that this could only be accomplished by a series of accurate measurements of the height of the coal itself, and the adjacent strata at different points throughout the country. From the peculiar character of the region, a knowledge of the dip is of little use for this purpose, being generally affected, if not

produced by the manner in which the incumbent strata have been cut through at the time of the original denudation of the country. The measurements which were made for this purpose were merely experimental, and their completion may be more properly left to a latter stage of the survey. Enough was developed to render it highly probable that this bed observes a nearly horizontal position, dipping very slightly to the southwest, with undulations running through it, from northeast to southwest parallel to the axis of the Chesnut ridge, and affording a miniature representation of what has taken place on a larger scale along the southeastern side of the whole coal field, near the Alleghony mountain. Over the most considerable of the lines of elevation, the only one which has yet been minutely examined, the upper beds of coal have been swept away, and the inferior strata exposed. The anticlinal axis alluded to, runs parallel to the western base of the Chesnut ridge, keeping usually within about seven miles of it. It may be seen about four miles west of Greensburg, Westmoreland county; passing thence southwest, it may be detected a few miles west of Mount Pleasant and Connelsville; three miles west of Uniontown, Fayette county, and in the vicinity of Mount Morris, Greene county. East of this line a few miles, the coal resumes its western dip, and is found regularly cropping out along the base of the Chesnut ridge, particularly near Uniontown, Connelsville, Mount Pleasant and Youngmanstown. Its northern outcrop is believed to be about five miles north of Pittsburg, passing through the northern parts of Westmoreland county, and that part of Beaver which lies south of the Ohio river. As we approach the Kiskiminitas, the coal is found on the summit of the highest hills, and the lower members of the series begin there to make their appearance. Whether the Pittsburg coal seam extends north of the Kiskiminitas is not known, as no examinations have yet been made in that district. Its extension in that direction is not however, probable, for the coal seams at Saltsburg, Leechburg and other places on the river, belong to the strata below the Pittsburg series.

A more full account of this inexhaustible bed will appear in my final detailed report, where all its Geological relations and its depth below the surface of the country, at almost every point as ascertained by measurement and calculation can be exhibited by the aid of drawings and Geological maps.

No. XVIII, Shale.

Reposing directly upon the coal seam, we observe a bed of shale passing generally, but not always into the overlaying sandstone.—The line separating it, and the roof-coal is usually well defined. In the neighborhood of Pittsburg, where it forms in connexion with the next member of the series, the summits of the hills, we find it a brown friable and compact shale of a ferruginous appearance. In common with other strata, it is composed of a mixture of sand and clay, the shale enclosing sandstone layers of greater or less thickness, which increasing as we ascend, in number and size, pass gradually into a compact sandstone. In the northern part of the district, this stratum is remarkable for the quantity of mica that it contains, which causes the sandstone layers to split into large slabs, with a glittering micaceous surface and imparts to them at the same time a crumbling texture. In other situations it abounds in vegetable impressions, apparently the stems of arundinaceous plants, &c. Very frequently, particularly in the lower part, it is a very soft brown and black shale, readily disintregating and has a splintery fracture. breaking off in long, thin prismatic fragments like the splinters of decaying wood. The surface is often covered with an efflorescence, a part of which is copperas. There are two varieties of this encrusting matter, the first, a salt of a pure white color in delicate crystals, and a greenish yellow mass, into which the former passes, by longer exposure to the atmosphere.

In Fayette county, it contains a thick bed of compact, distinctly laminated black shale, resembling in the harder parts, a roofing slate, the other layers are very soft and black. This includes a layer of coal one foot thick. Similar bands from one to several inches in thickness, are often observed running irregularly through it. Iron ore in small quantity is not rare in it, either dispersed in irregular nodules or in thin layers. The most considerable deposit of this kind, hitherto observed, is in Connelsville township, Fayette county, where it imbeds two layers of argillaceous ore, the uppermost a band of blue nodules, each from one to two feet broad and four inches thick. The whole stratum varies much in its dimensions, being in some places very thick, and in others only from five to ten feet. It may, however, be estimated at thirty feet average thickness.

No. XIX, Sandstone.

At various places along the Monongahela: for example, in the vicinity of Brownsville, and higher up the river, we behold a heavy bed of sandstone resting on the preceding. It is in general, a grey slaty sandstone, alternating with layers of brown and black shale. It varies much in compactness and thickness. Frequently it can be observed from a great distance forming white ledges along the hill sides and the banks of the larger streams. In the southern part of the district we find it in its greatest developement, being there frequently quarried as a building stone. Quarries of this rock are opened at Williamsport, on the Monongahela, and at several other points. Some layers of the stratum afford a fine stone of a light grey and yellow color, but of variable texture. Others are full of ferruginous concretions which render these bands difficult to dress. Carbonized remains of the ancient vegetation of the coal are not uncommon in this stratum but no other fossils have been observed. On the steep banks of the river and in other situations, particularly at the mouth of Ten Mile creek, and for some distance lower down the Monongahela, the sandstone appears to rest immediately upon the coal. Such appearances are not unfrequently caused by slides, which bring down the heavy sandstone shelf, over the soft and yielding beds of the intervening shale. It is not improbable, however, that No. XVIII is sometimes wanting, and that the present stratum is to be found in contact with the Pittsburg coal seam. Average thickness twenty-five feet.

No. XX, Shale.

Directly over the sandstone there lies a stratum of yellow and brown shale, imperfectly laminated with layers of sandstone, alternating in it. One portion of this rock is sometimes a tough and hard slate of a greyish color, containing grains of pure quartz. When soft, it is frequently pressed down upon the underlying sandstone, whose cavities and fractures it fills in a singular manner with a mass of ferruginous clay, shale and sometimes impure coal. No part of this stratum seems fit for building purposes. Thickness twenty feet.

No. XXI, The Great Limestone Deposite.

This is the most extensive and valuable calcareous deposite in the valley of the Monongahela or any where else in the western counties of

the state, for the limestone beneath the Pittsburg coal is comparatively thin and of little importance, as a source of lime for masonry or agriculture. This ample stratum, however, affords an inexhaustible supply wherever it is exposed in any part of the district. From the vicinity of Pittsburg, to the southern state line, and from Chesnut ridge to the Ohio river, it may be traced continuously, either on the summits of the hills, or what is more frequent, forming shelves or natural pavements along the beds of the smaller streams. It is a non-fossiliferous deposit, no fossils having been hitherto found imbedded in it, notwithstanding the frequency with which it has been examined in tracing its range through the country. The variation in the thickness and particularly in the composition of this stratum is remarkable. It consists of numerous beds of limestone separated by thin seams of shale. These beds are sometimes in contact, at others they include thin layers of shale from one to eight feet in thickness. Instead, however, of these partings of shale, we occasionally meet with dividing bands consisting of a sandstone which is calcareous, effervescing slightly with acids, and passing sometimes insensibly into the limestone.—The limestone itself, is generally of a blue color of various shades, is excessively hard and breaks with a semi-conchoidial fracture. At other times the layers are black or light yellow, and contain transparent specks of crystalized carbonate of lime. The latter variety is frequently very beautiful, and apparently hard enough and fine enough in texture to receive a good polish. If so, it would make a handsome ornamental marble, although the thinness of the layers would interfere with its extensive use for architectural purposes. The black kind is very hard, of a slaty structure, and gives out a fœted or bituminous odour when bruised or struck. This kind is generally found in contact with the interposed black shale. In some instances it passes insensibly into it, when the shale becomes a black calcareous slate, splitting readily into smooth plates and effervescing freely when touched with an acid. Most generally the shale is very soft, of a deep blue or yellow color, imperfectly laminated, and decomposing readily into a soft clay. Not unfrequently, it contains layers of calcareous nodules. Occasionally, it is very soft and black, resembling the outcrop of a coal seam. In the southern part of the district, instead of shale we find two thin layers of *coal* separating the limestone beds. The largest of these is two and a half feet thick, and has been opened in several places as a *coal* seam. Over what extent of coun-

try it will prove to be continuous, must be determined by future observations. The coal is of a good quality, very hard, breaks into lamellar fragments, and is separated from the layers of hard limestone by only a few inches of black slate. This band of coal has the appearance of being compressed by the limestone. By way of distinguishing it we may entitle it the limestone coal seam. The other band embraced by the limestone, is about one foot thick. It is probable that several thin seams of coal of a few inches in thickness would be observed in this stratum if the crumbling nature of the dividing shale did not tend to conceal them. In these shaly partings we sometimes meet with layers of limestone, in nodules of a large size and regular form, as if in these portions of the deposite, there had not entered quite enough of calcareous matter to produce a continuous bed of limestone. The consideration of these appearances, would, if we had space for the discussion, throw some curious light on the original formation of this important stratum.

This well characterized member of the series is readily recognized, and is very generally exposed in the ravines and hill sides, but being a rather variable mass as regards its minuter features, it is by no means easy to ascertain in every case, its precise composition. The quarries established in it, are generally mere strippings of the upper layers. Such is the case with those in Wilkins and Monongahela townships, Allegheny county, where the rock seems to thin off towards its northern outcrop. An idea of the manner in which it varies, may be obtained from the following sections:

Section taken at Brown's run, near Germantown, Fayette county.

1.	Hard blue limestone in layers,	18 feet.
2.	Blue and black shale, "	15
3.	Limestone and calcareous shale,	5
4.	Coal, 2½ feet with one foot of black slate beneath,	3½
5.	Hard blue limestone,	5
6.	Sandstone in layers,	10
7.	Slate, upper part soft, lower black and laminated,	3
8.	Hard blue limestone in layers,	6
	Whole thickness 62 feet,	65½

Section measured at the south branch of Ten Mile creek, near Jefferson, in Greene county.

1.	Limestone in layers,	12 feet.
2.	Shale, soft and blue, full of calcareous nodules,	4
3.	Grey sandstone layer,	1
4.	Limestone in layers,	7
5.	Calcareous sandstone, passing into the limestone,	7
6.	Blue limestone in layers,	20
	Thickness, 51 feet.	51

Section at Brownsville, in Fayette county.

1.	Limestone, hard in layers,	25 feet by estimation.
2.	Shale, black,	5
3.	Sandstone, slaty,	18
4.	Black calcareous slate, regularly laminated,	8
5.	Limestone, slaty,	6
6.	Hard blue limestone,	10
	Thickness 72 feet.	72

It is not, however, in every part of the district, that this deposite attains this full developement. In Allegheny, and the northern part of Westmoreland county, it is met with, covering the highest hills with its lower layers. These are sometimes seen capping the insulated summits of the hills, and forming a natural pavement, completely detached from the surrounding strata. Advancing towards the south, we find it gradually sinking under the hill tops, and showing itself lower down on the sides of the creeks and small streams, and becoming at the same time thicker.

Along the western base of the Chesnut ridge, this stratum rises to the surface, with a gentle inclination, in company with the other members of the series, being well exposed on the Loyalhanna and Youghiogheny rivers.

Appearing as it does on the Ohio river, at Wheeling, it is not improbable that this is the same bed of limestone described by Dr. Heildreth, as No. XXIV, in the first annual report of the Geological survey of Ohio. This description applies to it very exactly.

There are but few of the streams or even small runs emptying into the Monongahela, from Elizabethtown to the Virginia line, along which this stratum is not well exposed, its beds either forming a series of horizontal steps or patforms in the smaller water-courses or steep and smooth escarpments on the hill sides. On its almost incalculable value to the agriculture of our southwestern counties, I need not dwell, but I cannot refrain expressing a sincere regret that the importance of lime, as a fertilizer should continue to be so much overlooked. It is proper in this place to observe that the shales between the limestone beds themselves, are frequently very calcareous, and are consequently, in many cases, a genuine *marl*, both as respects their composition and their agency upon the soil.

No. XXII, Shale.

Resting on the upper part of the preceding limestone, there usually occurs, a thin, but well marked bed of shale, of varying thickness. The predominant colors are blue and yellow, and it is soft and imperfectly laminated. A bed of coal one foot thick has been detected in it, but this is not continuous. Thickness ten feet.

No. XXIII, Flaggy Sandstone.

The next rock in order is an important bed of sandstone distinguished by its slaty and thinly laminated structure, in consequence of which it affords an abundant supply of beautiful flagstone, It is well exposed at the town of Brownsville. The flags are obtained by splitting the rock with wedges and can be procured of any size from the thickness of one-fourth of an inch to one foot or more. It owes its slaty structure and ready cleavage to the abundance of mica, distributed in thin sheets through it. It is generally fine grained and of a light grey color. Good flagstones are obtained from it at Brownsville and other places. The flaggy structure being owing to the accidental presence of mica—when this ingredient is wanting or deficient in quantity, the rock then becomes a compact sandstone, and the lower part is sometimes quarried as a building stone. Vegetable impressions abound in it in some localites. Its general thickness is about fifteen feet.

No. XXIV, Shale.

Over the above we find a bed of shale, generally of a brown or

yellow colour, and often containing vegetable impressions. This stratum has not everywhere been recognized; the overlying limestone next to be described, sometimes resting on the preceding sandstone.

No. XXV, Upper Limestone.

This is a deposit of limestone, similar in character to the great deposite, No. XXI, but of less thickness and greater uniformity of composition. It consists of five or more layers of hard blue limestone, separated by a parting of shale, which is generally four feet thick, and which contains calcareous nodules and in one instance a layer of coal about one foot in thicknees. Thickness of the whole mass about eight feet.

No. XXVI, Sandstone and Shale.

We come next to a very important but variable bed of sandstone and shale. In Greene county it is a solid bed of sandstone, of a light grey color, and is generally coarse grained. In other parts of the district the sandstone is in thin layers, from one inch to two feet in thickness, separated by soft yellow and brown seams of shale.—When the arenaceous layers are abundant, the stratum is a true sandstone, but when deficient, it passes into a bed of shale, the change depending upon the greater or less quantity of sandy particles present in the mass.

There is some reason to believe, that this stratum contains a seam of coal, three feet in thickness, which may probably be the one seen at Brownsville, at Limetown and at Elizabethtown, and which occurs at various points upon the hills in the northern part of Washington county. The precise situation of this seam, we have not yet been able satisfactorily to determine, nor has it been possible indeed, to ascertain whether it is not identical with the limestone coal seam just mentioned. This stratum is very little exposed, in many places the shale being easily buried by the fallen materials of the hill sides. In the eastern part of Greene county, this coal is not seen; there the stratum is a thick bed of alternating sandstone and shale, and is well exposed beneath the upper coal seam, to be mentioned presently. Owing to its occurring frequently in regularly divided layers, from a few inches to many feet in thickness, it can be obtained in handsome flags, which are of a light grey color, are slighly micaceous and easily worked.—Thickness thirty-five feet.

No. XXVII, Shale.

This underlies generally the upper coal seam, to be next alluded to, but sometimes it is very thin or even entirely wanting. It is a soft yellow shale, full of calcareous concretions, and the upper part adjacent to the coal is frequently converted by the weather into a soft blue clay. Thickness five feet.

No. XXVIII, Coal.

We have now arrived at a seam of coal, that for importance, ranks next to the Pittsburg seam, every where throughout the southern part of the valley of the Monongahela. Although affording generally a coal of very excellent quality, it is not worked except in Greene county and the adjacent parts of Washington county. Over the northern portion of the district it has been removed from the surface by denudation. It is about six feet thick and rests on the preceding shale, or where that is absent on the underlying sandstone. It is divided near its centre by a band of soft shale, which varies much in thickness.—The lower part of the seam affords the best coal, and with care in extracting the slate, it forms an excellent fuel; the upper part is less pure, and has a slaty structure breaking into pieces of a prismatic shape. The adjacent slate is very full of pyrites, frequently containing large nodules of that mineral, by the decomposition of which copperas is abundantly produced, forming a coating on the surface of the coal and the included shale.

This seam of coal is met with in the high hills in the neighborhood of Brownsville, and also about two miles east of Waynesburg, in Greene county. Here it is seen in the bed of south Ten Mile creek, emerging from beneath the elevated ridge of country which extends through the centre of that county, and forms the high land which separates the tributaries of the Ohio river from those creeks which empty into the Monongahela. Passing beneath this table land it is again met with, as it re-appears on the western side of the county along the south fork of Wheeling creek, a few miles from the State line.—From the vicinity of Waynesburg, it spreads through the eastern part of Greene county, where it is worked extensively in Jefferson and Cumberland townships. This bed of coal will, when the country becomes more thickly settled, and better cleared, be considered a highly valuable deposite and will then be found to have a much wider range than is now attributed to it.

No. XXIX, Shale.

Overlying the previous coal seam, we notice a bed of brown and yellow shale. It is of great thickness and seems to have been compressed by the superincumbent sandstone. On the south branch of Ten Mile creek, it in some places becomes very thin, though even there it is a well marked stratum. Generally, it is covered with an incrustation of impure copperas, and small quantities of iron ore are sometimes enclosed in it. It is often but two feet thick, separating the coal at its outcrop from the overlying sandstone. Average thickness ten feet.

No. XXX, Coarse Brown Sandstone.

This is the largest bed of sandstone belonging to the upper part of the series. It is met with at Brownsville, in the high hills on both sides of the river, and extends thence through Fayette and Greene counties to the state line. This stratum is best developed in Greene county, where it extends from Waynesburg eastward to the river, capping the highest hills in the neighborhood. At Brownsville where it has been quarried it occurs as a coarse brown sandstone of a singular aspect, varying much in texture and composed of minute water-worn grains of white quartz. Two varieties of the rock may be distinguished, the first has a brown color consists of large grains held together without any apparent cement, and on exposure to the atmosphere, crumbles rapidly into a coarse sand of a sharp grit. The other variety has a finer grain, is of a grey color, and would make a good building stone.

In Jefferson and Franklin townships, Greene county, where this member of the series is well exposed, it forms a thick and massive stratum. In some places it is a soft slaty sandstone, externally of a yellowish colour, but in other situations its texture is coarse and the prevailing color a dark brown. Large blocks of it are frequently strewed over the hills. Occasionally it graduates into the underlying shale, but in general its inferior surface is well defined, it being a very compact and heavy rock.

This stratum in the northern parts of its range, has been stripped off from the surface by the action of the retreating waters. On the high hills adjacent to Hillsborough, in Washington county, rounded boulders of a coarse sandstone are found, which have evidently been

derived from this stratum; in like manner in Menallan and Redstone townships, in Fayette county, similar blocks are found, scattered in large fragments over the tops of the highest hills. Average thickness thirty-five feet.

OF THE STRATA ABOVE THE PITTSBURG SERIES.

It is believed that no part of the district contains rocks superior in their order of stratification to those just described, if we except the narrow belt of country a few miles in width, which forms the dividing land between the Ohio and Monongahela rivers, and which extends from the town of Washington southward, through Greene county to Dunkard's creek, on the Virginia line. The hills here are generally high, and not well cleared, affording few exposures adapted to minute Geological examinations.

So far as they have yet been investigated, these upper strata consist of thin beds of shale, sandstone and limestone, imbedding no deposites of much value, excepting iron ore, which there is reason to believe exists in some of the upper shales. When engaged in this portion of our exploration, the season was too far advanced to enable us to make any very satisfactory examinations. I may, however, subjoin the following section, the only particular enumeration of the strata above No. XXX, that we have been able to construct from actual observations and measurement. It is of course imperfect, but will be rendered complete in the detailed investigation, which this district will require hereafter.

Section.

31.	Shale, blue and friable,	7 feet.
32.	Coal, 20 inches, this is worked in several places,	
33.	Shale, blue, with calcareous nodules,	3
34.	Limestone in layers,	4
35.	Shale, soft, blue and badly laminated,	4
36.	Limestone in three layers,	4
37.	Shale, blue and yellow,	10
38.	Sandstone, very slaty, splitting into thin layers,	20
39.	Shale, brown and blue,	10
40.	Coal,	1
41.	Shale, brown and blue,	4
42.	Sandstone,	20

This section is the result of observations made in Waynesburg, in Greene county.

OF THE COUNTIES NORTH OF THE OHIO RIVER.

Transferring our attention in the next place, to that region of the state which lies north of the Ohio and west of the Allegheny rivers, let us enter upon a brief enumeration of the strata, as developed in this northwestern portion of the basin.

The lateness of the period in the summer, when the explorations in this district were begun, owing to unavoidable delay in procuring the services of a competent assistant, combined with the extent of country, which it was necessary we should traverse in the way of reconnoissance, preliminary to a systematic and detailed survey, besides certain impediments, incident to the examination itself, arising out of some local irregularities in the stratification, have all conspired to prevent our arriving at as complete a knowledge of the range, and relative positions of the rocks, and their imbedded mineral deposites, as we obtained in the more easily explored region of the valley of the Monongahela. Nevertheless I am enabled to present such a sketch of the Geology of this portion of the basin, as will shew the nature and situation of its mineral resources, and convey a general idea of the progress already made in the exploration; which, in reference to the state at large, is indeed the principal objects of my annual reports. In a section of the State, where the investigation, may be said to have been only commenced, there are many local facts and numerous and minute measurements already recorded, which are necessarily too incomplete, to make it proper to refer to them at present. They are reserved in order to incorporate them with fresh details to be hereafter collected, when their utility and their important practical bearings, (now liable, possibly to misinterpretation by some who are unacquainted with the proper mode of tracing the mineral deposits of an extensive region,) will justify any present delay in submitting them to the public.

STRATA OF THE NORTHWESTERN PART OF THE STATE, WHICH LIE BELOW THE COAL MEASURES.

For reasons already stated, these will claim at present, only a passing notice. Adopting as a convenient Geological boundary, the escarpment facing the northwest, or in other words the northwestern slope of the line of hills, which stretches from near the state line, north of Warren, southwestward by Meadville, to the

neighborhood of Sharon, we shall find the country included between that limit and Lake Erie, embracing chiefly Erie county and part of Crawford, to consist of strata of our formations VIII, XI and X, but principally of those of formation VIII. Minute research may possibly enable us to detect hereafter in the thin seam of arenaceous limestone, found near the base of these hills, at Meadville, evidence of its being the final thinning away of formation XI, already described, as exposed along the southeastern side of the basin, on the flank of Chesnut ridge. The line of hills above traced, marks the extreme northwestern margin of our great bittuminous coal field, being capped by the conglomerate of formation XII, generally the immediate sub-stratum of the coal measures. The inferior destructibility of this rock, compared with the softer ones between it and the lake, by causing a less degree of denudation of its surface by the retreating waters, is the reason of its forming the edge of the table land upon which all the coal reposes, in a very gentle inclination to the south or southeast.

The easily decomposed shales and argillaceous sandstones of formation VIII, have furnished much fertile soil, to parts of Erie, Crawford, and the adjoining counties; thin bands of more or less pure limestone, occasionally imbedded in this formation, deserves to be especially examined, in order to learn their true range and position, and to detect any possible connexion they may have with the valuable deposites of calcareous *marl*, so abundant in some of the low grounds of this region, Pymatuning and Conneaut swamps for example. An attention to whatever may bring to light in these localities, the existence of so useful a fertilizing material, must be important to the practical objects of the survey, and will influence in part, our future researches in this region.

Approaching the base of the chain of hills, capped by formation XII, we meet with slates occupying a rather higher place in the series, which judging from many of their external features, seem to be referable to formation IX, and a portion of them, probably to formation X. There is a difficulty in defining, at least at present, the respective limits of these three formations, or indeed in establishing unequivocally the separate existence of the two last. In truth, strong doubts may be started, whether the alternation everywhere more or less observable, between formations VIII and XI, and also IX and X, may not comprise in the part of the state now before us, nearly the entire mass

of this portion of the series, implying a more intimate blending of the several materials, as they reached this part of the bed of the ancient sea, than took place in districts more to the southeast, where they have been separately super-imposed.

A reference to the stratification, as we behold it in the vicinity of Meadville, will tend to convey a tolerably exact conception of the nature of the beds of rock which, occupy the four hundred feet of depth below the base of the conglomerate stratum, (formation XII,) which there caps the hills, forming part of the general margin of the coal field.

These hills on the north and south of the town, are at their greatest elevation, four hundred and eighty-eight feet above the bottom of the canal, and expose the upper strata, especially, with some degree of distinctness. The lower ones are not so continuously exhibited to view, making it more difficult to determine their true order of succession.

Near the level of the canal, the beds are of brown slate and sandstone, and over this we find a thin bed of clayey shale, then the sandstone repeated, and then another layer of red and grey shale, two or three feet thick. Near the outcrop of this bed of clayey shale, a spring issues near its upper surface, encrusting all the rocks beneath it, with a coating of carbonate of lime. At a higher level are seen thin beds of calcareous shale, some of which abound in fossil shells, and other organic remains. From this shale to the height of one hundred and fifty feet, occur alternations of coarse, brown sandstone, and thinly laminated bluish slates, and flaggy olive sandstones and olive slates. At that height we meet a bed of blue shale four feet thick, and over it brown sandstone and olive slate, until we reach two hundred and thirty-five feet. Here we encounter a bed of *sandy limestone* two feet in thickness, which as it is a peculiar rock, and remarkably continuous for so small a stratum, deserves particular notice. It is compact and exceedingly hard, containing a large though variable proportion of siliceous or sandy matter. It lies in large and nearly square masses, the angles of which are more or less rounded off, owing to the readiness with which the lime is dissolved, out of the rock. By the removal of this ingredient, and the oxidation of the iron in the stratum, it acquires a brown siliceous crust, sometimes thick, indicating it is to be feared, too large a proportion of sandy matter, to qualify this rock to be converted into even an impure lime. In an attempt once made, the excess of sand in the

rock, produced with the lime a slag. In such cases, a more moderate degree of heat, will sometimes prove more successful. Under the limestone, in a massive bluish sandstone, we find thin layers of an impure *iron ore*.

Ascending from the limestone, we pass thick beds of brown and bluish sandstone, some of which latter are slightly calcareous, thin beds of fossiliferous and calcareous slate, succeeded by others of brown and blue shale.

At the height of four hundred and twelve feet, we arrive at the base of the great bed of conglomerate, consisting of sand and of siliceous pebbles, never larger than a common marble or a large pea. The same rock is seen at the height of four hundred and fifty feet. Its soil is different from that of the rocks beneath it, being said to be better fitted for wheat, and sustaining a luxuriant growth of chesnut trees.

The hill to the south of the town, has a less elevation than that to the north, by nearly fifty feet, but as the soil here contains scattered fragments of coal; a fruitless search was once attempted for coal, which a moderately shallow boring, would have shewn could not exist.

On French creek, seven miles southeast of Meadville the conglomerate caps the hills, which are there very high.

Of the general face of the country, on the northwestern side of the coal field, it may be instructive to make some mention in this place, as tending to assist in forming a correct notion of the position occupied by the coal and other mineral resources in this quarter of the state. In the western part of Mercer and Crawford counties, the table land supporting the coal measures, is intersected by long, straight and rather wide valleys of denudation, leaving the upper shale, containing the coal in long parallel intersecting ridges, which range in a north by west and a south by east direction. The largest streams pursue the valleys, merely crossing through the ridges, out of one valley into the next, but the small tributaries rising in the hills, find their way transversely down their flanks by ravines, into the main valleys. From the Ohio river northward, the general plane of the country, gradually rises, but with a very gentle inclination. From the mouth of the Beaver, to the surface of the Conneaut lake, the ascent is only four hundred and eighteen feet. The tops of the highest

hills near New Brighton, are about five hundred feet above the Beaver at its mouth. At the bend of the Shenango, where the canal is two hundred and forty-one feet above the mouth of the Beaver, the hills rise three hundred and ninety-five feet more, making six hundred and thirty-six feet above the mouth of Beaver creek; and Pymatuning ridge in Mercer, is about fifty feet higher than these. At Meadville, the canal is four hundred and twenty-three feet, and the hills nine hundred and thirteen feet above the former point, the mouth of Beaver. We perceive therefore, that the actual ascent of the plane, including the summits of the hills, from the Ohio river to the margin of the coal basin, hardly exceeds four hundred feet. Nevertheless, gentle as this rise in the land towards the north appears, it has the effect of spreading out the valuable beds of coal, iron ore and other materials in that direction, over a much wider space, than they would have covered, had the surface of the district been entirely horizontal. After thus supporting the lower strata of the coal measures this gently inclined plane, sinks suddenly to the lower plane or terrace which borders in a broad belt, the southern shore of Lake Erie, the surface of which is only eighty feet lower than that of the Ohio, at the mouth of the Beaver. Throughout almost the entire extent of this upper plane, the lowest bed of coal with its accompanying iron ores, still clings to the surface, and though discovered in few places, will ere long, it is believed, be developed at many points, where its existence is not now suspected.

Along the line of the canal from the Conneaut lake to Sharon the coal already found in many places, will be traced and ultimately opened in a multitude of localities; for the lines of levelling which have been executed, shew that the coal rises but little more rapidly to the north than the surface of the country itself. One valuable locality where it can be readily mined, and from which it might be conveyed away by the canal with great facility, would be the Bend hill, on the Shenango. Although the coal has not yet been discovered at this point, the measurements and observations made, tends to give considerable confidence, in its being soon found there, if the excavations be judiciously conducted.

The subjoined estimate is presented for the sake of shewing the advantages to this section of the state, which may be anticipated from an early developement of its coal beds, which situated on the northern margin of our coal field, have open to them, so soon as the She-

nango shall be finished, the boundless market of the region of the lakes.

Expenses of mining and transporting the coal from the Shenango to Erie and Buffalo.

At the mouth of the mine the coal will here cost per bushel,	1½ cts.
Cost of delivering it from there into the boats,	1
Transportation to Erie, including lockage,	6
Whole cost delivered in Erie, per bushel	8½

The present market price of coal in Erie is twenty-five cents.

To convey it on to Buffalo, would swell the expense about two cents more per bushel.

Sharon, the neighborhood of Clarkesville, and of Greenville, and other places similarly well situated, with these and the Bend hill, will supply the northern market with coal, under circumstances of expense at once highly advantageous to our own citizens, and to the consumers, to whom this excellent fuel is becoming daily more indispensible.

At a point about eight miles west-southwest of Meadville, and three miles south of Conneaut Lake, coal is found and the conglomerate, (called in this part of the State the "Pebbly rock,") occurs exposed about three fourths of a mile to the southwest. Upon levelling the surface between these places, the bottom of the coal was ascertained to be level with the top of the conglomerate, but the real direction and the extent of the trivial dip in this place has not yet been determined.

The coal which lies near the surface, has been opened only recently, and of course near the outcrop is somewhat broken. It is, however, of excellent quality, especially for the use of the blacksmith, being of a bright lustre and pure. The bed measures from three and a half to five feet in thickness. This coal sells at Meadville for seventeen cents per bushel.

About one hundred feet below the conglomerate in this vicinity, a bed of blue shale contains many seams of an impure variety of iron ore of the kidney form. A bed of arenaceous limestone, closely resembling that at Meadville, occupies at this place, the same relative position, to the overlying conglomerate which it has there, being about two hundred feet above it. The sandstone overlying it, is also, very similar, though it abounds more in the fossil vegetable impres-

sions called *fucoides*. In this neighborhood, there are many high hills, which promise an abundance of coal, though the inhabitants, have never until now, suspected its existence. The natural exposures are not good, and a very critical examination made by the aid of instruments, will be requisite before its exact position can be ascertained.

Iron ore has been found near the coal, and below the conglomerate. Travelling towards the south and southeast, the conglomerate and coal gradually descend in height to the level of the lower hills.—Three miles southwest of Greenville, coal is found at Yockstemmer's, two hundred and forty feet above the bottom of the canal, from which it is distant a mile and a half to the westward of it. It here lies very irregularly, showing a difference of level of seven feet in the space of a few rods. It is about three feet thick, and of the variety called *slaty cannel coal*. At this point the conglomerate lies above the coal now spoken of, separated from it, by from twenty to twenty-five feet of argillaceous strata.

At Georgetown, the conglomerate, coal and iron ore are all found a little below the highest summits of the vicinity. The coal is about three feet thick, of a dull black, and in structure and aspect, is a slaty cannel coal. Iron ore in great abundance has been thrown out in excavating the drift at the mouth of the coal mine. Above the coal to the height of about twelve feet the, hill side abounds in fragments of a bluish conglomerate, containing the usual white pebbles, but the adjoining sandstone is more sparsely studded with them. In many places in the neighborhood of Georgetown, the conglomerate well marked in all its characters, is seen overlying the coal. Between them, there usually lies a shale containing several seams of excellent iron ore. Two in particular, which are separated by only a foot o shale, measures in aggregate thickness, twelve inches, the upper one seven inches, the lower, which is of a beautiful blue color and fine texture, five inches.

A small furnace is now erecting to smelt the ore, (a mile or more, however, from the spot where the foregoing measurements were made.)

It is of a rather novel design. The blast is to be propelled by a steam engine in which the steam will be generated by the heat supplied from the stack of the furnace, to which the boiler is to be attached. It is a small quarter stack furnace, and is, strange to say, with one exception, the only furnace in Mercer county.

Along the margins of several runs which enter the Little Neshanock, our explorations brought to light a bed of arenaceous limestone, exactly corresponding in its position and quality, to the seam already alluded to, as occurring at Meadville, and Conneaut lake. Not far below it, my assistant, Mr. Hodge, found at Mr. Milnor's, where the township line crosses the Little Nêshanock, a bed of blue shale from ten to fifteen feet thick, containing *eleven* layers of iron ore of pretty good quality. The aggregate thickness of the ore was estimated at a foot and a half. The shale appears to be adapted to making a good fire brick.

This neighborhood seems to possess claims as an iron manufacturing district, not only from the abundant supply of good ore in it, but from its capacity to furnish a competent quantity of charcoal, much of the land being still covered with an exceedingly heavy growth of hard wood. Bog iron ore has been found in considerable amount, but its purity is somewhat problematical.

Approaching the town of Mercer, on the turnpike, we soon encounter a thick bed of sandstone, which is of various colors, or red and mottled, in its upper portions. It is full of thin streaks of iron ore, which impart to it a peculiar feature. Near its base the stratum is very white. It lies above the conglomerate, and its thickness is at least one hundred feet. Half Moon Swamp lies below this, its level, being about the position of the coal bed. This sandstone stratum passes under the town of Mercer.

A bed of slaty cannel coal like that at Georgetown, has been discovered at a place called Orangehill, in Pymatuning township.— About two hundred feet below it, we found a bed of arenaceous limestone one foot thick, one mile and three quarters from this coal, east, nearly thirty-three degrees north, the same bed is exposed twenty-three and a third feet higher in level, giving a dip of thirteen and one-fifth feet to the mile, estimated in the direction west, thirty-three degrees south, though this may not be the direction of the maximum dip of the stratum. The land between rises to the height of one hundred and ten feet above the lower coal bed. This is also the height of Pymatuning ridge, where search has been made for the coal seam, by digging numerous shallow pits at one and a fourth miles southeast by east of the spot where it has been opened, but without success. On levelling from the coal to this spot, the conglomerate was passed lying about fifteen feet above the level of the coal.

Should the coal be found hereafter below the lowest stratum of brown shale, which is above the conglomerate, it will prove that a sensible dip or what is far more probable, a dislocation of the strata occurs in the intervening distance, equivalent to a descent of forty feet to the mile, in a southeast by east direction.

SANDSTONE STRATA, AFFORDING QUARRIES ALONG THE SHENANGO.

In the neighborhood of "Big Bend," some important quarries of sandstone have been opened to supply materials for the construction of lock No. 15, and the dam near it, belonging to the Shenango navigation.

The first of the quarries is at an elevation of about one hundred feet above the canal, and one mile higher up the valley than the lock. The stone is employed in the slope wall and bridge piers. It is a firm, bluish sandstone, slightly calcareous, and lies in a solid mass, thirty feet at least in thickness. It may be quarried in blocks, whose greatest thickness is about two feet. A temporary rail-road conveys the stone upon little trucks, regulated by a break. This is the most convenient quarry to the canal. The stratum extends down the valley to Sharon, three miles above which it is quarried in another place, and it occurs at Meadville, where stone has also been extracted from it. It may be readily recognized, by its bluish tint and slightly calcareous properties. Between this rock and the conglomerate which overlies it, at a considerable height, there is a massive stratum of brownish sandstone, which might be readily quarried on the Shenango, if it were thought desirable. It yields good stone two miles south southwest from Conneaut lake.

Both these valuable strata, not making their appearance at the surface near lock No. 15, the contractors not being aware that they range in nearly the same continuous plane under all the hills, have passed over them on the northern side of the Shenango, while they have gone beyond the siliceous conglomerate to establish a quarry in the thick bed of sandstone on the very summit of the hill, which is here nearly four hundred feet high. To procure some of their stone, they even go down on the *other side* of the hill to the conglomerate, simply because it was there exposed. Directly opposite, they pass over all the lower beds of sandstone unheeded, to the conglomerate, and until recently, they passed by this and continued a mile further, by an expensive road constructed expressly for the purpose, to pro-

cure their stone from the stratum of the red and variegated sand stone exposed on one of the highest summits of the Shenango hills.

On the top of the Keel ridge, four and a half miles from Sharon, the same bed of red and variegated sandstone shows itself, and is quarried to be taken thence to lock No. 6, below Sharon, a distance of at least four miles, whilst an inexhaustible supply of stone, certainly as fit for the purpose, might be procured in the immediate vicinity of the work from the other strata enumerated.

The above details are introduced, for the purpose of impressing upon the engineers, the great importance to the state or to the companies constructing public works, of themselves exploring somewhat in detail the stratification in the neighborhood of their surveys, and of doing this prior to issuing their proposals to contractors.

The contractors on the works of internal improvement in the United States, are at present a large majority of them, new in their business, and untaught even in even the rudiments of practical Geology, a subject of all others, the plainer principles of which it behooves them to understand. The consciousness of this makes them uncertain of a supply, in every case of apparent difficulty, in procuring their materials, and operates as a tax, and often a very heavy one, on the state or other parties constructing the work. Add to this the consideration, that many of them come from distant quarters at short notice, just before a letting, to make a hurried inspection of a region, the soil, the rocks, the whole structure of which, are probably entirely new to them, and we shall perceive sufficient reasons why the average rate of their biddings must exceed what it would be if they had better knowledge. I would respectfully point out, that engineers have it in their power, in almost every instance, by undertaking a previous exploration, made methodically, and in accordance with Geological principles, to impart such information to contractors, as would procure from them much more economical prices for their work, and insure for them in return a fair remuneration for their toil, with a greatly reduced amount of risk in fulfilling their contracts. It is palpably unwise to pay, as the public now does, a premium—sometimes a very exorbitant one—to cover risks which a little research would often remove, and which too, generally have their only origin, in the inexperience of the contractor.

FOURTH ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF PENNSYLVANIA:

BY HENRY D. ROGERS, *State Geologist.*

Printed by order of the Senate, February 8, 1840.

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1840.

SECRETARY'S OFFICE, Feb. 8, 1840.

Honorable Wm. T. Rogers, Speaker of the Senate.

SIR, I have received the fourth Annual Report of the State Geologist, and have on this day transmitted the same to the House of Representatives, in compliance with the Acts of Assembly upon the subject of a Geological Survey of the State.

I am yours, respectfully,

F. R. SHUNK,

Secretary of Commonwealth.

To the Senate of the Commonwealth of Pennsylvania.

In submitting herewith my Annual Report on the Geological Survey to the Legislature, I avail myself of the opportunity to offer a brief statement of the degree of forwardness of the work and the prospect of its early and satisfactory completion.

Though the several acts of the Legislature, making appropriations for the prosecution of the Survey, to continue in force for five years from the commencement, specify no period within which the investigation shall terminate, yet it has been my earnest wish and effort from the beginning to complete the survey as nearly as practicable, in the time to which the present appropriation is limited. I am happy that the advanced condition of the several branches of the work authorize my expressing to the Legislature my confident hope of bringing to a successful close all our researches in the field, by the expiration of the five years mentioned, ending the 1st of April, 1841. I beg leave also to mention my anticipation of being able, during an extra season of six months, with a much diminished scale of appropriation, giving me the aid of a portion of my present corps of assistants, to arrange and bring forward the extensive body of detailed results of the survey in a properly methodized shape. This period of six months will, it is hoped, suffice for the production of my final Report, the completion of the Geological Map of the State, and numerous illustrative drawings, together with an extensive train of chemical analysis of our ores, &c. now going on, and also for the organization of the Geological Cabinet, which will amount, it is believed, to between six and seven thousand specimens.

My present Annual Report, the first in which I have entered into a detailed description of our mineral resources, will, it is hoped, shew the practical direction and bearing of the Survey in all its departments, and by its size, (two hundred and fifty pages,) make manifest the necessity of the six months asked, for the production, in a digested form, of my final Report, embracing all the minutiæ of the Survey from the beginning.

With sentiments of great respect,

HENRY D. ROGERS,

State Geologist.

REPORT, &c.

To the Secretary of the Commonwealth.

SIR:—I beg leave to submit to the Legislature, through you, in accordance with my instructions, the following Report of the operations of the Geological Survey of the State, during the past year. In doing this, I shall confine myself, as heretofore, to a statement of the progress which has been made in the several departments of the Survey, and to a general account of the structure and resources of the different districts which have been explored, introducing only such details as are likely to be intelligible, without the aids and illustrations intended to accompany the final minute and systematic description of our Geology. Those illustrations will comprehend the Geological Maps of the entire State and of some of its more intricate regions, the numerous sections designed to exhibit the stratification and position of the mineral deposites in each formation, and an extensive series of detailed chemical analysis, intended to show the true composition and relative economical value of the numerous ores, coals, limestones, cements, clays, building materials, mineral waters, &c. collected in the progress of the exploration.

The active field operations of the Survey were commenced about the middle of April. Pursuing the system of investigation adopted at the commencement of the previous season, examinations were carried on in five of the six districts, into which for convenience sake, as mentioned in my last Annual Report, the State had been divided.

Those members of the corps engaged in exploration, embracing nine Geological Assistants, were distributed over these several divisions in the following manner.

The First district, including all that part of the State lying south and east of the Kittatinny valley, was allotted to Messrs. Holl and Trego; the former aiding me in the exploration of Bucks, Philadelphia, Montgomery, Delaware, and Chester counties, and the southern townships of Lancaster; the latter in the whole of York, and Adams.

In the Second district, comprising the north-eastern half of the Appalachian region of the State, including all the country between the South mountain and the Allegheny mountain, and between the Delaware and Susquehanna rivers, terminating on the latter at Muncy creek, I was assisted by Messrs. Whepley and Leslie, the investigations embracing many points of intricacy, particularly in the Pottsville coal basin and the valley north of the Blue mountain.

The task of constructing a detailed map and sections, intended to exhibit, when completed, all the anthracite coal fields of the State, calling for a minute examination of the topography, and an exact tracing, as far as practicable, of every recognizable seam of coal, constituted an important part of the seasons's operations in this district. The resignation of Mr. Whelpley, about the first of July, somewhat retarded the investigations essential to a thorough acquaintance with the highly complicated features and vast mineral resources of these extensive coal fields; nevertheless, I entertain a confident hope of being able to bring this part, together with the rest of the Survey, to a satisfactory termination, in two more seasons, at farthest—furnishing a map and numerous drawings, calculated, it is believed, to prove highly useful to all those in any way interested in the development of the mineral treasures of the region.

In the Third geological district, or that which constitutes the south-western half of the Appalachian region, lying between the Susquehanna river and the southern line of the State, and between the South mountain and the Allegheny mountain, and embracing numerous productive deposits of iron ore and other minerals, together with a valuable coal field, the explorations have been vigorously prosecuted. The detailed examination of the Cumberland Valley and its bounding ridges, devolved upon Mr. Trego, while the exploration of Mifflin, Huntingdon and Bedford counties, together with parts of Union and Centre, was divided between Messrs. M'Kinley, Henderson and Jackson. Mr. M'Kinley devoted himself to a central belt including the Seven mountains, part of Kishacoquillas valley, the whole of Stone valley, and the valleys and ridges from the eastern base of Sideling Hill to Tussey's mountains, closing his operations among the coal seams of Broad Top mountain. The termination of the season, prevented our advancing further towards the south-west. Dr. Henderson gave his attention to the belt of country south east of the last, including the greater part of Mifflin county, and the eastern townships of Huntingdon and Bedford, lying between Sideling Hill and the Tuscarora and Cove mountain. Dr. Jackson took the western portion of the district, comprehending the country situated between Tussey's mountain, and the base of the Allegheny mountain, terminating his operations for the season in the vicinity of Bedford.

In the Fourth district, embracing that part of the State which lies between the eastern base of the Allegheny mountain and the summit of Chesnut Ridge, or the western Laurel Hill, and between the Southern State line and the Bellefonte and Brookeville turnpike, no explorations were undertaken. A laborious and tolerably minute reconnoisance of this wooded region had been made during the previous season, and it was deemed advisable to postpone the examination of its somewhat obscurely developed coal fields until a greater degree of progress should have been made, in ascertaining the true relative situation of the coal seams, beds of iron ore and mineral deposites generally, in other parts of the same great bituminous coal formation throughout the more open country, lying further to the west. By

adopting this order of research, making the better known geology of the vallies of the Monongahela and Allegheny, the key, which it truly is, to the at present, more obscure resources of the district in question, I conceive that the temporary pause in the examination of this district will be productive of increased accuracy in the knowledge we shall acquire of its mineral deposites, and tend materially to expediate this portion of the survey. It is proposed to resume the investigations in this district during the ensuing season with increased facilities for research.

The Fifth district, comprehending all that part of the State lying west of Chesnut Ridge, and the eastern boundary of Armstrong and Venango counties, was entrusted to Messrs. M'Kinney and Ward, who assisted in the exploration of Venango, Armstrong, Butler and a large part of Mercer and Beaver counties, and who were likewise employed in collecting a mass of minute and valuable information along a line of country extending from the base of Chesnut Ridge, through parts of Westmoreland and Washington counties, to the Ohio river at Wellsburg. A detailed section was surveyed along the tract here alluded to, commencing on the turnpike east of Mount Pleasant, following afterwards the Big Sewickly creek to its mouth, and thence crossing from the Youghiogheny to the Monongahela above Williamsport, and following the latter river to the mouth of Mingo creek, and this stream to its source. Beyond this, its direction was north of west through Cannonsburg to Cross creek, and down this stream to the State line and across to Wellsburg. The examinations made along the line here traced, being instituted for the purpose of ascertaining the true positions relatively to each other and to the surface of the adjacent country of all the accessible coal seams and other useful mineral deposits between Chesnut Ridge and the Ohio river, were performed with the aid of instruments designed to impart to the results as great a degree of accuracy as practicable. The elevation of each seam of coal, and the intervals between them, were ascertained for a great number of places along the line of this section by a barometer and barometric thermometer, both of superior accuracy, while the distances between the stations of observation were measured after the usual manner, by the chain and compass. The extensive measurements thus made, enable us to calculate by the information they afford respecting the true dip of the strata, and the undulations of the surface, the depth for any particular spot, along the line of section and over a considerable extent of adjacent country, of every important bed, even when it lies buried under several hundred feet of other strata. By availing ourselves of the data thus collected and instituting when necessary, other similar instrumental measurements across the out crop of the rocks which compose the western counties, we shall give it is hoped to the exploration of the fifth or western district of the State, during the approaching season, as high a degree of accuracy as can be deemed essential for all useful purposes. Pursuing the plan of research thus commenced, it is believed that the coming season will not only bring to light every useful mineral

band in the formation, however unimportant its thickness, whether coal, iron ore, limestone, fire clay or sandstone, but determine with sufficient precision its situation below the surface throughout the whole of the wide region referred to.

In the examination of the Sixth district, which includes the wild and wooded country bounded on the north by the northern line of the State, and on the south by the base of the Allegheny mountain and the Bellefonte and Brookville turnpike, I was aided by Messrs. Hodge and Stone, the latter gentleman, though not a member of the corps, contributing his services as a volunteer for seven months in a remarkably arduous campaign with considerable advantage to the progress of the survey. Owing to the wilderness condition of much of this northern district, it was found indispensable to use a tent, and to aid our operations by employing two men in the duties incident to a camp life.

The business of these persons was to transport provisions, together with the tent and instruments, either on their backs, when it was necessary, as it most frequently was, or with the aid of a pack horse, wherever there was a road. In a region, the geology and geography of which was very imperfectly known, no systematic course of investigation could be pursued, until a certain amount of information was previously collected concerning its local and general features. After an arduous reconnoisance, it was discovered that the *coal measures*, the principal object of interest in this district, do not form, according to the common belief, one general basin, embracing all the high grounds north of the Allegheny mountain; but occur in a series of small, separate coal fields, confined to the most elevated portions of the region. This important fact being determined, a clue to the position of the coal was soon acquired; saving much labor and time in our subsequent researches. It was soon seen which belts of country demanded a minute investigation, and which authorized a less laborious study. Wherever openings into the coal had been already instituted, or where new ones could be undertaken by ourselves, without too great an expenditure of time, every effort was made to ascertain, as accurately as possible, the number, thickness, and quality of the coal seams, and the order of their superposition. In the wilder tracts of the country, wherever previous research had proved the possibility of the occurrence of the coal measures, a minute inspection of the ground was made; and if any tokens of the existence of a coal bed were noticed, either in the character of the rocks, or in the discovery of the coal slate and smut in the channels of the brooks or in the upturned roots of fallen trees, regular diggings were undertaken, and the position of the coal bed proved. In this way, several seams, hitherto unknown, were developed; and it is believed no important deposite within the region has been passed over undiscovered. That portion of Lycoming county north of the Susquehanna river, between Farrandsville and the Loyalsock, with the exception of a small district bordering this creek—also, the whole of Tioga county, and that part of Clinton county lying on the Tangascootack—have been in this

manner examined, with as close a degree of scrutiny as was compatible with the nature of the country, or usual in researches of this sort. Only a few additional researches, of a general character, remain to be made. A revision of certain parts of the tract thus explored will, it is hoped, establish the true situation of some of the smaller beds found in a few places, about which some uncertainty still prevails, and enable us to complete those observations of the topography requisite to the proper construction of the geological map.

Distributing the investigations in the several districts among the different members of the corps after the manner thus specified, my own duties consisted in superintending the operations in each quarter, either in regular rotation, or in such order as the intricacies and difficulties of the research made most desirable. Directing, and personally sharing in, the operations of the Survey in each district, I am enabled by the above organization to satisfy myself of the accuracy of the observations reported to me, and to contribute, at the same time, my own examinations in aid of those of my assistants in all cases of doubt and difficulty, and to concentrate, if necessary, an extra amount of aid to points which, from their importance and intricacy, require instrumental measurements, or much detailed research.

By adopting the mode thus briefly sketched, and retaining the present organization in the several departments of the Survey, I hope, as each individual in the Survey has now acquired a familiarity with the peculiar structure and local features of the particular district which has been assigned to him, and with the nature of the difficulties to be overcome, to be able to complete nearly the whole of the field investigations, by the close of the next season, leaving but few tracts in the State, of any geological interest, unexplored.

In stating to the Legislature the prospect of so early a completion of the operations in the field, I deem it my duty, at the same time, to mention that an additional season, but probably not an entire year, will be required for finishing various branches of the Survey unavoidably delayed by the active and engrossing duties hitherto essential to the progress of the exploration. For the purpose of revising many intricate portions of the work, where a clue to the stratification has been discovered during the subsequent examinations made in neighboring tracts, and for conducting a number of measurements necessary to the settlement of important practical points remaining still in doubt, this final season will be important. It will be indeed indispensable for the production of the general final Report, and for completing the geological map of the State, and the local maps and geological sections intended to exhibit the situation of the mineral deposites of each district, and for finishing the analysis of a vast number of ores, coals, and other useful substances, collected during the prosecution of our researches.

In the chemical department of the Survey, the analytical operations have been vigorously prosecuted. The Chemical Assistant, Dr. Robert E. Rogers, and Martin H. Boye, having been enabled, by improved arrangements in the labortary, to perform an extensive

series of valuable analysis, disclosing the chemical composition of many of our ores, coals limestones, and other useful substances, and developing a number of important facts connected with their practical applications in the arts. It is believed, that by the end of the autumn of 1841, contemporaneously with the proposed close of the other departments of the Survey, the chemical work, conducted as at present, will have made known the nature of every material, of any value, within the State, and shown its adaptation to useful purposes. The detailed analysis will, in all, amount to several hundred. By affixing to each specimen examined, a record of its chemical composition, and by placing it in the State cabinet, at Harrisburg, the value of the collection will be greatly enhanced for all purposes.

The specimens collected for the State cabinet during the past year comprising a large body of ores, coals, limestones, cements and other minerals, occupy one hundred and thirty boxes and amount in all to about three thousand pieces. The whole body of specimens hitherto collected during the survey may be estimated at about eight thousand, about four thousand of which, form the contribution hitherto made towards the general State cabinet, which is hoped will ultimately amount to six or seven thousand, and embrace every thing appertaining to our geology and our mineral wealth. The specimens thus far gathered have been opened and temporarily classified and arranged for the purpose of having them as accessible as possible, both for analysis and for reference while framing the annual and final reports on the survey. Upon the termination of the field work, when the collection shall be completed, the requisite analysis performed, and the final report prepared for the press, the whole will be conveyed to Harrisburg, where it is intended permanently to place it for the use of the public. Until then, little advantage, it is conceived, would arise from depositing the specimens in the State Capitol, as they would require to be re-arranged every time an addition were made to their number by the annual gathering, and as they would prove moreover, comparatively useless for reference before the appearance of the final and detailed report, inasmuch as it and the cabinet are designed mutually to elucidate each other.

Should the Geological Survey be completed in the autumn of 1841, as I confidently hope it can be, it will then have occupied five years and a half. The appropriation for the last half year need not I conceive amount to more than five thousand dollars, the operations of the final season admitting probably of such a reduction in the corps, as not to require much more than one half the present scale of expenditure.

CHAPTER I.

Sketch of the Geology and Mineralogy of those parts of the First or South-eastern district, explored during the past season, comprising Bucks, Montgomery, Philadelphia, Delaware, Chester, part of Lancaster, and the whole of York and Adams counties.

The physical feature of the south-eastern district included between the north-eastern base of the South mountains, and the eastern and southern boundries of the State, are, throughout its southern and central portions, those of a moderately undulating plain, interrupted by few abrupt elevations; while along its northern side we have a broad belt of rounded and swelling hills and ridges some of which attain considerable height.

The rocks comprehended within this extensive area belong, for the most part, to the stratified class; embracing many varieties of both primary and secondary origin. The unstratified rocks of a crystalline structure occur either in the form of small local and irregular veins, or of dykes of greater or less magnitude, intruded through the strata. They include several varieties of *granite*, *sienite* and other similarly constituted rocks, all in thin veins traversing chiefly the primary strata along the southern side of the district, and also, several species of trap rocks, the larger and longer dykes and ridges of which, range principally in the belt of country south of the South mountains and within the Red Sandstone formation. The stratified rocks of the region, occupy a succession of narrow parallel belts, which generally observe a direction from E. N. E. to W. S. W. most of which range entirely across the district from the Delaware river to Maryland. The first of these formations, beginning our enumeration on the south-east, as a broad belt, composed principally of gneiss, mica slate and talc slate and their subordinates varieties which occupy the space between the tide water and the southern margin of the great limestone valley of Chester and Montgomery counties, and its prolongation east and west. To this succeeds the interesting calcareous formation of the valley just referred to, which consists of a more or less crystalline limestone, obviously like the former rocks belonging to a primary date. To the north of the range of this limestone, there occurs, occupying some of the northern townships of Chester county, another large area of gneiss rock. With the exception of this tract, all the formations north of the line in question rank themselves in our Lower and Middle Secondary state. Thus the sandstone which form the North Valley Hill, Mine Ridge, the Welsh mountain, Chickey's Ridge at the Susquehanna, Milbough Hill, and the hills between Reading and Allentown belong to F. 1. of the Lower Secondary or Appalachian series, while the limestone of the central townships of Lancaster county, and of the interior of York county,

refers itself to F. I. of the same group. The red shales and sandstones which traverse the central and northern parts of the district from the Delaware river to Maryland, constitute our middle secondary rocks. These comprise a large part of Bucks and Montgomery, the northern side of Chester near the Schuylkill, the southern townships of Berks, the northern part of Lancaster, the southern side of Lebanon and Dauphin and the northern townships of York, together with a wide tract extending through the centre of Adams.

In presenting a sketch of that large and important part of the district which has been examined during the past year, I propose adopting as far as practicable a uniform order in the description of the several formations, commencing with those on the south-eastern side and advancing successively towards the north-west. The detailed delineations of each belt, as far as this will be attempted, will in nearly every instance be pursued from the N. E. towards the S. W. or longitudinally with the general course of the rocks.

Section I.

Gneiss and Mica Slate, with their associated Rocks and Minerals.

The first or south-eastern division of the primary stratified rocks, comprehending the gneiss, mica slate and talc slates situated south of the limestone valley of Montgomery and Chester counties, commences in New Jersey, in a narrow point about six miles to the E. N. E. of Trenton, expanding gradually in its course towards the W. S. W. until it forms a broad belt occupying the whole of the southern townships of Chester, Lancaster and York, where it leaves our State and passes into Maryland. The south-eastern margin of the formation crosses the Delaware at Trenton, where it is well exposed, forming the falls of the river. In this vicinity it consists chiefly of a dark hornblendic gneiss, dipping at a rather steep angle to the S. S. E. Along its course for several miles south-westward, a deep covering of diluvium, conceals a large portion of the belt, and precludes our discovering its local features.

Crossing the Neshaminy about a fourth of a mile south of the road leading from Attleboro to the Buck tavern, in Southampton township, occurs the most eastern exposure of the primary limestone in this quarter of the State. It is in the form of a small oval or lenticular bed, occupying an area not exceeding one half an acre, upon the farm of Mr. Van Arsdale. The bed corresponds in its dip and direction with the strata which surround it. A dyke consisting, chiefly of *Labrador Felspar*, has been protruded through it, and seems to have altered its structure, producing in it, near the line of contact, several minerals, usually foreign to the composition of limestones of this character, such as *graphite* (or *black lead*), *tabular spar*, and *oxide of titanium*,[1] *Actinolite* and *augite*. North-east of the Buck tavern, occurs a dyke of close grained trap. Rather more than a

mile south of the Buck tavern, on the banks of the north branch of the Paquasin creek, there is a locality where Plumbago, or black lead, was formerly worked, but the place is abandoned, and the pit filled up. Near the bridge at Rockville, a granite vein is seen; and in the creek, the gneiss contains several minerals, not unfrequently met with in this locality. Among these are *zircon*, *crystallized oxide of iron*, *dark green*, *mica* and *blue quartz*. Where the road from Davisville to Huntingdon intersects the county line, there is an extensive *trap dyke*, running nearly east and west, in a straight line; for three miles. The gneiss in its vicinity assumes very much the character of a sienite, and promises, in some places, to be useful as a building stone. A little to the south of this, we encounter the south-eastern extremity of a narrow belt of a somewhat peculiar rock, consisting chiefly of felspar, which takes a W. N. W. direction across the old York road, about a fourth of a mile north of Willow Grove, and afterwards conceals itself beneath the overlaying middle, secondary red sand stone. *Zircon*, *titanium*, and *oxide of iron*, are occasionally found in small quantities in the boulders of gneiss and other rocks in the neighborhood of Willow Grove. Included among the hornblendic gneiss of Trenton, and the ordinary granite gneiss and mica slate of the lower part of Bucks and Montgomery, there occurs a somewhat remarkable stratum of felspar rock, well exposed in a quarry on the west side of the Delaware. This material is applicable to several useful purposes, being much employed in Trenton as a flag and curb stone, and furnishing a material much better fitted, by its compact structure, for MacAdam roads, than the softer and more granular rocks which adjoin it. It consists, merely, of felspar and quartz, not separately crystallized, but intimately blended and interfused. It sometimes contains a little talc, together with crystals of *schorl* and *oxide of iron*. Its ordinary color is a light straw yellow. The prevailing dip of the stratum is to the S. S. E., at a steep inclination. Its course is west by south, passing north of Falsington, through Oxford, to Mather's Mill, on the Neshaminy; thence nearly westward, across the road leading northward from Smithfield; after which, entering Montgomery county, it soon begins to expand in width, becoming, when it reaches the Old York turnpike, between Abington and Willow Grove, about a mile and a half broad. About a third of a mile west of the turnpike, it separates into two portions; the northernmost, two thirds of a mile wide, passing westward along the course of Sandy run, and finally disappearing beneath the margin of the middle secondary red sandstone; the southernmost, having a less breadth, taking a S. W. direction, and forming a ridge which skirts the limestone valley, on its south, from this point to the Schuylkill, near Spring Mill, where the stratum at last thins out. A part of this ridge, two miles N. E. of the Schuylkill, is called Barren Hill, where the peculiar rhomboidal structure sometimes seen in the rock is well exposed. In that portion of the formation which passes through Bucks county, several quarries have been opened, the rock being there capable of furnishing a tolerably good curbstone.

The greater portion of the southern and eastern sections of Philadelphia county, shows a deep covering of diluvium, concealing the gneiss and its associated rocks, except where they are exposed in the vicinity of the streams. In this part of their range, the primary strata are much traversed by veins of coarsely crystalized granite, in which the three ingredients, the *felspar*, *quartz* and *mica*, are often of unusual size, the felspar being generally by far the most predominant mineral, and exhibiting a remarkable tendency to pass to the condition of *kaolin*, by decomposition. This rotting, by atmospheric influence, is not confined to the injected veins of granite, but characterizes also a large part of the gneiss, especially in the country around Philadelphia, where the rocks are sometimes in a decayed and pulverulent condition to a depth of more than twenty feet. Advantage is occasionally taken of this circumstance, the loose materials of the rock being sifted to procure a sand which is of remarkable sharpness, and well suited for the purposes of masonry.

At Fairmount, near Philadelphia, the gneiss projects above the diluvium, and is quarried to some extent in this vicinity, and also on the west bank of the river, at Judge Peters's. The grain, or lamination of the rock, is exceedingly contorted; implying the occurrence, at one time, of an immense compressing force. In all the quarries from Fairmount to the Falls of Schuylkill, the rock is intersected by numerous cross joints, which appear, until closely examined, to represent its divisional plains or true stratifications, and which at Fairmount are nearly horizontal. These joints divide the mass into blocks of convenient shape and dimensions; and when they dip in the right direction, greatly facilitate the operations of the quarry. The belt of gray granitic gneiss which passes Philadelphia, is well developed on Darby creek, Crum creek, Ridley creek, Chester creek, and the other adjacent streams. On nearly all of these, it has long been wrought, supplying Philadelphia, and other places, with a large amount of very excellent curbing stone, and material for the foundations of houses and for other purposes. At the Falls of Schuylkill, there is a large quarry of very excellent gneiss, of a light gray aspect, which has long contributed its supply of good building material to Philadelphia. In this quarry is a vein of large grained granite, with red felspar; the strata dip to the N. W. Higher up the Schuylkill, the relative proportion of the felspar in the rock is less, while the amount of mica is greatly augmented. Nearly the whole distance from Fairmount to Manayunk, the prevailing dip of the rocks is towards the north, with only occasional irregularities. Approaching the mouth of the Wissahiccon, *garnets* begin to be abundant; and the rock assumes, for considerable spaces, the composition of a true mica slate. *Staurotide*, *cyanite*, and *red oxide of titanium*, with other minerals, occur in this vicinity.

Near Manayunk the predominant rock is a mica slate. It is much contorted and abounds here and for two miles up the river, as far as the soap-stone quarry in regularly formed crystals of garnet. It is also intersected by numerous veins of coarse *felspathic granite*.

At the tunnel on the Reading rail road, and near the Flat Rock bridge a belt of considerable width crosses the river north of which the mica slate is again repeated, embracing between this point and the belt of soap-stone, one or two smaller zones of the hornblendic rock.

The so called, *soap-stone rock* referred to, crosses the Schuylkill about a mile and a half above the Flat Rock bridge. Its average width is a little more than a furlong. This stratum includes two distinct bands, that on the south being mineralogically a rather peculiar rock, consisting of *steatite* and *talc*, imbedding numerous lumps or knots of dark *serpentine*, while that on the north, is a dark variety of *serpentine* holding occasionally crystals of hornblend. The *steatitic rock* has been quarried for many years on the east bank of the river, supplying Philadelphia to a moderate amount, with a material excellently adapted for the lining of furnaces, grates and fire places. Until the general introduction of marble, it was also used to some extent for the steps of houses, for which, however, it is not so well adapted, the soft steatite being easily worn and leaving in course of time the harder nots of serpentine to roughen the surface.

The steatite and serpentine belt first shows itself near the foot of Chesnut Hill, three fourths of a mile east of the Germantown turnpike. Increasing in width, it crosses the Wissahiccon a short distance below the intersection of the same road where it is well exposed. At this locality it contains *green mica. talc, stealite, dolomite, serpentine* &c. in abundance. On the Ridge road, a few detached fragments, in the soil of the neighboring fields, are all that can be found to indicate its course. Approaching the Schuylkill, the *serpentine band* augments considerably in width, forming a distinct ridge which extends into Lower Merion township. At the soapstone quarry on the Schuylkill, the dip of the steatitic rock, appears to be parallel with that of the mica slate lying south of it, but it is so much intersected by cross joints as to render it difficult to determine this point with certainty. Between the steatitic rock and mica slate there occasionally occurs a thin band having nearly the composition of a chlorito slate. *Crystallized dolomite, carbonate of lime* and *talc*, occur here abundantly. About half a mile west of the Schuylkill in Lower Merion township, there is another quarry which has likewise been worked for many years. The steatite at this locality can be procured in larger blocks, being less intersected by joints: it frequently contains, however, concretions of *carbonate of lime, dolomite* and other minerals which deteriorate its value. About a mile and a half further west, the belt expands to nearly half a mile in width, separating soon into two portions, which cross Mill creek about three furlongs asunder, and then thin out. The serpentine throughout the whole range, maintains nearly the same features, being much mixed with heterogenious minerals. No distinct line of division separates it from the steatite on its south. North of the serpentine range the gneiss again appears, traversed as usual, by veins of granite. Further north, the character of the rock is entirely changed, it having hardly the aspect of a crystalline or primary stratum. This bed is traceable from the river to the Bethlehem turn-

pike. On the west side of the Schuylkill, it forms a high ridge, dividing the gneiss and mica slates on the south, and the talc slate and limestone on the north. Not far west of the river *hematitic iron* ore exists near it, though not in large deposites, and on the Gulf road ore was worked for some time. Traces of iron ore are frequent in this part of the formation.

Not far from Bellemont the beds of hornblendic gneiss and mica slate contain much injected granite passing to the state of *kaolin*, one vein of which is from twelve to fifteen feet in thickness. On the Lancaster turnpike about four miles from Philadelphia, there is a locality where it is thought the gneiss might be profitably worked; it was exposed in cutting the new rail road. In the northern part of Blockley township, the hornblendic variety of the gneiss is quite abundant. The townships of Lower Merion, Haverford, Maple, and also the south of Radnor, are composed chiefly of mica slate. In Upper and Lower Providence, Springfield, Darby, Upper Darby, and in Ridley townships, gneiss and mica slate mostly prevail. In the northern part of Lower Merion and Radnor, there is a similar rock to that on the Schuylkill above the serpentine band. It becomes talcose towards Tredyffrin.

On the road from Chester to West Chester, through Edgemont, about three miles from the former place, the beds assume a scientific aspect, a circumstance which is not unfrequent. Its structure implies rather a *metamorphic* than an *igneous* origin. Gneiss and mica slate through which extensive trap dykes have been protruded, are often modified into a rock of similar character.

Near the Blue Hill school house in Upper Providence township, there is a small bed of serpentine, and at the cross roads in Middletown townships, rather more than a mile from Wrangletown, *jasper*, *calcedony*, *flint*, *hematite*, *steatite*, and other minerals occur in the serpentine formation which appears to constitute the hill which crosses the Chester and West Chester road diagonically from S. W. to N. E. The trap dykes that occur in Delaware county are mostly small and rarely influence the strata in their vicinity. One of some size occurs in Newtown.

Near the Spread Eagle, on the Lancaster turnpike, fourteen miles from Philadelphia, there exists a small included bed of serpentine, a little to the north of the main road. No exposures of the rock are visable, but it is distinctly marked by its sterile soil which has caused it to be abandoned by the agriculturist. On the north of this lies the talc slate, which passes so gradually into the mica slate on its southern margin as to render it impossible, unless in particular instances to delineate them separately. The upper or northern margin of the talc slate belt, bounding the primary limestone on the south, is distinctly marked, being generally near the base of the South Valley Hill. This band of primary slates pursuing a W. S. W. direction in the range of hills south of the Great Valley, expands from a width of one mile at its eastern extremity, to a breadth of several miles as it approaches the Susquehanna.

Another bed of serpentine, similar to that near the Spread Eagle, occurs in the mica slates about a mile and a half S. W. of the Paoli, and about one-third of a mile further on in the same direction, there is a large bed of the same rock, nearly two miles in length, which crosses the road from Saugartown to the Warren tavern, and thins out in East Goshen, not far from the township line. North of Saugartown, it has been quarried, furnishing the material for the monument commemorating the massacre of Paoli. In the same range another included bed of the serpentine crosses the road leading from the General Green, to the Steamboat taverns. It is a mile and a half in length, and nearly a fourth of a mile wide. The rock at this locality contains *talc*, *asbestos*, *magnetic iron ore*, *steatite*, and *quartz* and in smaller granules, *amethyst*, *jasper*, *garnet*, *actinolite* and *schorl*. Another and smaller band occurs in a direct line with it, about a mile further west, thinning out at Taylor's mill on York run, where it has been quarried to some extent, supplying the building material for the Episcopal church in West Chester.

Serpentine has generally been ranked by geologists among the unstratified, igneous rocks, few instances being recorded where it assumes a regularly bedded structure; but in the belts above described, there is little, either in its relative position to the adjacent strata, or in the appearance of the rock itself, which imply that it has been intruded in a melted state. Its aspect is that of a strictly laminated rock, the divisional plains conforming to the stratification of the surrounding mica slate. This is particularly conspicuous at the quarry last alluded to. We perceive, moreover, no evidence of any contortion in the neighboring schistose rocks, such as would indicate the protrusion of this material. The mica slates, and included serpentine, all dip at a high angle, towards the S. S. E. In the township of West Goshen, occur *carbonate of magnesia*, *magnesite*, several varieties of *quartz*, *cyanite*, *staurotide*, *asbestos*, *amyanthus*, *steatite*, *talc*, and *octohedral crystals of iron*, at several localities, but generally in small quantities. In East Bradford township, a few furlongs west of the forks of the Brandywine, we meet with another bed of serpentine, somewhat more than a mile in length. It is exposed on the road leading from West Chester to Wistar's bridge. Near Strode's mill, there occurs another bed, apparently a portion of a different belt. About two miles north of the forks of the creek, on the road leading from Wistar's bridge to the Gap road, we pass a barren hill, which consists of serpentine; and another tract similar occurs on the road from Marshallton to Trimble's mill.

On the Fork run, a mile and a quarter from its juncture with the Brandywine, exists a small lenticular bed of *limestone*, included among the layers of the mica slate. It does not exceed half an acre in extent; but it is a useful locality, furnishing lime for the neighboring lands. In East Bradford township, besides most of the minerals found in West Goshen, we find *fœtid carbonate of lime*, *amethyst*, *zircon*, *brown tourmaline*, *adularia*, *actynolite*, *steatite*, and *lithomarge*. The dip of the rocks on the Brandywine, both in

the talc slates and mica slates, is precisely the reverse of that which they display on the Schuylkill, being generally S. S. E., at a steep angle.

Referring in the next place to some points in the geology of the district, south of West Chester and east of the Brandywine, we may mention the occurrence of an excellent *brickmaker's clay* worked in the vicinity of that town and at several other places. In Birmingham township, on the farm of Caleb Brinton, one mile west of Dillworthstown, the mica slate contains a small interposed bed of limestone, occupying about one acre. It is quarried, yielding a rock of a coarsely crystalline structure, which produces a very good lime. Some distance south of Dillworthstown, a narrow vein of a superior white felspar crosses the road leading to Wilmington, from which masses of considerable size and purity are obtained. Still further to the south, on the farm of Thomas Bullock, in Delaware county, we find another bed of limestone, somewhat similar to the last, though yielding a material of rather less purity. West of the Brandywine, we find the small lenticular *beds of limestone* becoming more numerous among the primary slates. On the farm of William Harvey, one mile above Chad's Ford, is a fine white limestone, containing crystals of *Brucite*. Another bed is quarried about two miles west of the creek, near the Pennsborough township line. It is somewhat larger than any previously described, and lies in the bottom of a valley. The rock is large grained, partly white and partly speckled by dark mica, or clouded by a little carbon. The bed, and the adjoining strata, dip to the south. According to Mr. Townsend, of West Chester, about four hundred and eighty perches of limestone were quarried in this township during the year 1838. Chrome ore, though only in small quantity, has been found on the farm of Joel Swain. *Arragonite*, *crystallized augite*, *sahlite*, and *sphene* crystallized in augite, were also found in this township. In the adjoining township of Kennet, about thirteen hundred perches are said to have been procured from the quarries of Caleb S. Jackson and Lewis Gansar; the former situated on Red Clay creek, three-fourths of a mile below Marshall's mill; the other on the Delaware line, on a smaller branch on the same stream. The rock, especially at the latter locality, is coarsely crystalline. At both places it is white, and contains *carbonate of magnesia*.

Another small lenticular bed of limestone is traceable near the meeting house at Kennett's Square, but it is not quarried. A fourth bed, of the same description, crosses the western line of Kennett township, about one mile south of the village. A large quarry exists here, on the farm of J. M. Phillips, the stone yielding an excellent lime. The dip, in all these instances, is towards a point a few degrees east of south. Two narrow bands of limestone, about a furlong apart, occur not far from Barclay's mill, higher up on the same stream. The northern and largest one consists of a firm, white and sometimes bluish limestone, containing carbonate of magnesia. These beds are somewhat contorted. On the farm of Thomas Webb, in this neigh-

borhood, a small body of *chrome ore* has been discovered, several tons only of which have been dug. A large limestone quarry has been opened on the farm of Mr. Logan. It yields a good lime. In East Marlborough township, several interesting minerals were met with. Among these are *zircon*, *basanite*, *fœtid felspar*, *beryl*, *epidote*, *tremolite*, and *dialage*, all occurring near Unionville; also, *chromate of iron*, *oxide of titanium*, *iserine*, *spongiform quartz*, &c. in other places. During twelve months, about seventeen hundred and twenty perches of limestone were quarried in this township. In West Bradford township, on the Brandywine creek, near Woodwards's mill, the slates enclose a bed of limestone; and in the same range, to the W. S. W. of this, there exists another larger one, which thins out in crossing the road from Downingstown to Marshallton, one mile north of the latter place. Limestone is also quarried near the Poor House, not far from the southern line of the township, where an excellent lime is produced. At this locality, we find *fœtid quartz*. Another small band of limestone, occupying perhaps a fourth of an acre, may be seen a little north of this, on the road to Marshallton. During twelve months, about four thousand perches of limestone were quarried in this township. A dyke of fine grained trap crosses the country east of Marshallton, in a S.S.W. and N. N. E. direction, forming a ridge of rather good soil.

In Newlin township, about five hundred perches of limestone have been raised in one year. This township is rich in a variety of minerals; among which we may enumerate, *precious garnet* in small quantities, *radiated quartz*, *chalcedony*, *agate*, *corundum* (both massive and crystallized), *green tourmaline*, *beryl*, and *sapphire ligeforum*, *asbestos*, *oxide of titanium*, &c.

In East Fallowfield township, near Laurel Forge, occurs a steatite rock, at one time quarried, but now only occasionally wrought. Serpentine, also, occurs on the road leading from Marshallton to Coatsville, near the interseetion of a small stream entering the west branch of the Brandywine, a little below the paper mill. Nearly the whole of this township consists of the talc slate formation, which crosses the east branch of the Brandywine above the mouth of Valley creek, and passes through the northern part of West Bradford, and thence expands in width through East Fallowfield into West Fallowfield, where the proportion of mica slate in the rock becomes considerable. On Doe run, in the latter township, there is a large quarry of excellent limestone, near the cotton factory. Though nearly in a line with the bed at Phillips's mill, one-third of a mile distant, it does not appear to be the same. In both instances, the dip is towards the south. The rock is bluish and white. Much limestone exists in this vicinity; and from indications, the beds are probably of some extent, though imperfectly exposed. In West Marlborough, the adjoining township, to the south, about eight hundred and fifty perches of limestone are quarried annually, obtained chiefly on Doe run. About a mile and a half north of Londongrove Meeting House, there is a bed of white limestone, containing in some abundance, a mineral, the

nature of which we have not yet determined. Among the minerals found in West Marlborough are dolomite, fluate of lime, magnesite, scapolite, radiated, crystallized and fibrous tremolite, &c. Limestone occurs in the southern part of the township, on the farm of William Penix, two miles to the north of Chatham. It has received but little attention. About half a mile south of Londongrove Meeting House, there is a small hill, consisting of a sandstone, referable, apparantly, to F. I. of the lower, secondary series. The rock dips to the S. E. and seems to be a small patch of that formation which has escaped denudation. Another hill of the same sandstone crosses the Wilmington and Lancaster turnpike, a little south of Chatham. In this latter tract, which is about a mile long and a fourth of a mile wide, the sandstone dips at an angle of forty-five degrees, to a point a little east of south. The occurrence of F. I. in this insulated position, so far to the south of its general margin, which is along the northern side of the Big Limestone valley, is somewhat remarkable, and implies how extensive was the denudation which removed the lower, secondary strata from the southern belt of the State, which they appear, in part at least, to have covered. Near Chatham, *asparagus stone (phosphate of lime)* may occasionally be found, and *oxide of titanium* more frequently. During 1838, the limestone quarried in this township amounted to fourteen thousand six hundred and eighty-four perches. A bed, crossing near the branch of White Clay creek, half a mile from Chatham, is extensively quarried. The prevailing color of the rock is blue, though occasionally it is white. It yields an excellent lime, and appears to cover a considerable area. About a mile south, a bed of the limestone occurs, immediately on the creek at Stephen's mill. It is small, and has not been much worked. Steatite rock exists in the same neighborhood. One mile south of Chatham, there is a small quarry of limestone, of a blue color, on the farm of William Hicks. Fine specimens of *ivory quartz* occur in this locality. A white, and sometimes brownish, granular limestone, often disintegrated, is seen on the farm of Phœbe Morgan, half a mile north of Westgrove Meeting House. A quarry of fine limestone lies further down the stream, near Jackson's mill; and a large quarry on the east branch of White Clay creek, near Avoudale. The beds here are thick; the rock close grained, and advantageously wrought, and of a bluish and white color, affording, when burnt, a good lime. Potter's clay abounds in this township; also, a little *iron ore*, and crystallized *red oxide of titanium*. In New Garden township, limestone occurs in several localities. One on the eastern township line, belonging to J. M. Phillips, has been already mentioned. Elfric Wilson has opened one on the road from the Londongrove Meeting House to the Friends' Meeting House, on the Wilmington turnpike, in New Garden. It is situated in a valley not far from the northern line, on the west side of the road. A very good stone is raised at this quarry, which is of a blue and white color. The beds dip to the south, at a steep angle. Dochranamon Hill consists chiefly of sienitic rock and mica slate, the latter being sometimes quarried for flag stones. Some

of the gneiss in this vicinity furnishes a good building stone. A narrow belt of limestone, yielding a tolerably good lime, is quarried about three-fourths of a mile south of the above mentioned hill. A bed of rather pure *kaolin*, from which several hundred tons have been procured, occurs on the farm of Samuel Hoopes, in the southern part of the township. It appears to be abundant, but the demand for the article is limited. In this neighborhood occurs *magnesian garnet*. About three-fourths of a mile from the Delaware State line, a bed of limestone was quarried on the farm of Thomas Brown. A section in the quarry shows the limestone in a nearly horizontal position, regularly overlaid by mica slate. It is granular, and liable to disintegrate.

Half a mile lower down on the same stream, a branch of White Clay creek, there exists a bed of impure micaceous limestone; quarried on the farm of Septimus Evans. Some parts of the quarry, however, afford a good material. The Waste Land quarries, so called, in this vicinity; are not much worked—the beds have the usual S. E. dip. A part of the rock is inclined to disintegrate, though the quality of the lime is rather good. The quantity of limestone quarried in this township in twelve months was upwards of two hundred and sixty thousand perches.

In London Britain township, there is an extensive belt of limestone. The rock is bluish and white, lying in thick beds. It is compact and produces a good lime. The whole yields from several adjoining quarries, seventeen thousand perches per annum.

Gneiss and mica slates traversed by occasional belts of hornblendic and sienitic stratified rock occupy the townships of London Britain, New London and the greater parts of East and West Nottingham, Upper and Lower Oxford, Londonderry, &c. The soil in some places is moderately fertile, but when the talc and mica slates prevail, and they constitute the predominate formation, it is not productive. In Londongrove near Morris's mill, a singular hornblendic rock occurs which might pass for a variety or sienite. Near Brown's mill, on Little Elk creek, in East Nottingham, we find the eastern extremity of that broad belt of serpentine rock known as the Pine Barren range. The southern margin crosses North-east creek between the cotton factories and the Maryland line. The northern margin passes almost due westward near Kirk's mill to Carter's mill, on the Octarora creek and thence to the Maryland line, at its intersection with the Conawingo. Chrome ore is found in small quantities in this belt not far from Ramsey's tavern, but not in abundance. It also occurs though not in quantity a mile and a half east of the tavern near a small brook which crosses the state road. By washing the debris which strews the bottom and margin of this stream—much chrome ore in a granular form is collected. Two excavations have been opened for the ore in the Pine Barren at Carter's mill, in West Nottingham, but the mineral was soon exhausted. In this township, during the year 1838, one hundred and fifty tons of chrome ore were procu-

red and about fifty tons in East Nottingham. Its market price is about sixteen dollars per ton.

Some of the more mottled varieties of the serpentine in the former township, are quite compact and susceptible of a polish, promising to be adapted to ornamental purposes. A short distance below Carter's mill on the Octarora, there is a seam of the *silicate of magnesia*, from which in 1838, about eight hundred tons of the mineral were procured, valued at four dollars per ton, at the quarry. It lies in the form of compact veins or lenticular beds, of no great thickness, mixed sometimes with steatite and serpentine, the quantity however, seems abundant. A little higher up the creek a narrow vein has been discovered where the mineral is intermixed with much serpentine and other substances giving it the mottled appearance of a *breccia*. The serpentine belt of this and the adjoining townships contains both steatite and asbestos, The serpentine ridge after crossing the Conewingo, and passing into Maryland, is prolonged in a W. by S. direction crossing the Susquehanna near Fraser's Point, and thence entering Harford county. Near the Octarora, not far from Wood's Fulling mill, Mr. Isaac Tyson has a large chrome pit which has been extensively worked for several years. The mineral does not occur in the form of a regular vein or load, but in bunches irregularly mingled among the serpentine on one side, but somewhat well defined on the other, having a general S. E. underlie or dip. The fragments of serpentine on the surface contain much chrome ore, and this locality promises a supply sufficient for the demand for sometime to come. Chrome ore exists also, though not abundantly, near the Baptist Meeting house, on the Maryland line, where steatite, often containing disseminated ore, occurs in great abundance. Asbestos is also common here. The indications are, that the cromiferous iron ore and other associated minerals exist in many places in the belt where they have not yet been procured.

The principal rock in the southern part of Lancaster county is talc slate. The soil resulting from this formation is generally sterile and unprofitable. On the Susquehanna river, a little above the mouth of Peter's rock, near Peach Bottom ferry, slate is quarried on both sides of the river. The strata dip toward the S. S. E. at an angle of seventy-five degrees; the lines of bedding and of cleavage coinciding. Irregular joints traverse them generally at an acute angle. The slates split with great facility.

Near Snedley's saw mill on Little Conewingo creek, occurs a small bed of serpentine embraced between strata of talc slate and mica slate, On the summit of a hill near the road, chrome ore and silicate of magnesia exist in small quantites. A pit was opened here, but is no longer worked. At the Methodist Meeting house, between Little Britain and Drumore townships, we meet with a small bed of curious felspathic rock analagous to that which bounds the primary limestone near the Schuylkill. It yields a good white clay but not in quantity sufficient to make it an object of importance.

Talc slate constitutes for the most part the rock in Colerain, Drumore, the lower part of Bart and part of Martick townships, being varied by a few occasional belts of mica slate. The soil is therefore poor and the country thinly settled. In Bart township the important limestone belt of the Great Valley thins out. On a line with this limestone is a small lenticular patch of the same rock known as Bears' quarries.

Having now completed the observations at present to be made, respecting that part of the southern primary belt which lies south of the Great Limestone valley, from the Delaware as far westward as the Susquehanna, I shall proceed in the next place to describe the primary tracts, lying north of the same valley, and between this latter river and the Schuylkill, then treat of the Geology of the Great Valley itself and afterwards extend my observations west of the Susquehanna into York county.

Gneiss North of the Great Valley of Chester county.

That part of Chester and Lancaster counties lying immediately north of the Great Limestone valley, is occupied chiefly by stratified primary rocks of the gneiss system. Much of this gneiss is of the granitoid kind, while many beds are hornblendic. The predominant constituent is felspar, though it presents a considerable variety in its composition. In Chester county, to which these observations more especially refer, it is usually rather coarsely crystalline, but in Lancaster, particularly toward the Susquehanna river, we meet with a larger relative proportion of mica and talc slate, replacing the genuine gneiss.

The junction of these gneiss rocks, with the primary limestone of the valley is concealed by the over lapping sandstone (F. I. of our lower secondary series) which forms the North Valley Hill, from the Schuylkill to the westernmost branch of the Octarara creek. On the north, the gneiss of Chester county passes beneath the middle secondary red sandstone formation from Valley Forge, to the eastern extremity of the Welsh mountain, and on the N. W. beneath the older secondary sandstone of the Welsh mountain itself. Mica and talc slates prevail in much less proportion in this tract than throughout the primary region, already described, lying south of the Limestone valley. In the parts of East Nantmeal, Vincent, Pikeland, Charleston and Uwchland, where the gneiss prevails, its character is very uniform; felspar, hornblend and quartz, being here the prevailing constituents, and mica relatively rare.

Iron ore has been dug here for several years past in several places, about five hundred tons being annually produced. In Vincent township, about six hundred tons are annually procured. It occurs at many localities east of the Yellow Springs, but no where in apparently large deposits. The composition of the ore found near the Yellow Springs, will appear from the analysis given in Chapter VI.

At Kimberton, on the farm attached to the Academy, and but fifty yards south of the road, there is a very small bed of altered crystalline limestone, consisting chiefly of calcareous spar, including scattered crystals of *plumbago epidate* and other minerals. It seems to have been a small lenticular bed into which a dyke or thick vein of sienite has been protruded, the excessive heat of which, when in a melted state has probably modified the rock to the crystalline structure described.

At another locality further north, near Shuter's mill, on French creek at the margin of the red sandstone occurs another bed, of highly crystalline sparry limestone, similarly affected by a dyke of igneous rock and containing beautiful crystals of *plumbago* and other minerals. The intrusive rock seems to be a species of serpentine. These beds of limestone have been wrought to a very moderate extent, the cost of qarrying them being considerable and the lime though fit for agriculture, being rather too dark for the purposes of the plasterer. The structure and mineral character of this calcareous rock, seem identical with those which characterise the belts of altered secondary limestone, which range so extensively along the southern margin of Kittatinny valley across New Jersey.

Small trap dykes are common in the townships of Vincent and East and West Nantmeal. The two high hills near Warwick Furnace consist of trap—the largest mass of this rock in the township. Nearly two miles below the Yellow Springs, on the road which leads direct to the valley, and on the middle branch of the Pickering, there is another, but much smaller, bed of limestone, which has been altered in a similar manner to those above described. The rock that surrounds it is a kind of sienite, and the limestone is crystallized and contains *plumbago*. A fourth bed of the same species of limestone occurs on a small branch of the Brandywine, one mile and a quarter north-east from the Eagle tavern. Like the others, it has been altered by igneous action, and is coarsely crystallized, and contains *plumbago*. Above the Friends' Meeting House, a bed of a singular, hard, hornblendic rock, crosses the road; appearing, also, on the road leading from the Yellow Springs to the Red Lion, two miles above the latter place. Pipe clay occurs in Uwchland township, in considerable abundance. Graphite is said to occur in West Nantmeal, disseminated through blue quartz, but none was met with.

Iron ore is found at several localities. Near Isabella Furnace, a vein of *titaniferous iron ore* occurs on the farm of Mr. Green, yielding 59.44 per cent. of metallic iron. The titanic acid which it contains, forming a titanate of the protoxide, renders the ore difficult to flux, and consequently the manufacture of iron from it has been abandoned. Large quantities of this ore were taken to the lower part of New Jersey some years since, for the purpose of mixing with the *bog iron ore* of that district, and was worked with some success. Its chemical composition is given in Chapter VI.

A little below Waynesburg, near Felt's mill, there is a dyke of trap, extending in a nearly east and west direction. On the road

from the Mariner's Compass to the United States Arms, one mile south of the Lancaster turnpike, there is a bed of limestone, which may belong to F. II., as it is situated on the margin of a hill of sandstone consisting of F. I. It is not altered: the color of the rock, which is fine grained, is a light blue. The area which it occupies is limited. In this township, fifteen thousand perches of limestone are said to be quarried annually.

In Brandywine, and the greater part of West Caln township, hornblendic rocks are common; but in Sadsbury, in Lancaster county, gneiss, usually the granitic kind, and mica slate, are the prevailing strata.

If we trace the line of junction between the primary rocks and the limestone F. II,, we shall find it commencing near the western extremity of the Welsh mountain, on the southern side of the hill, and passing near the Pequea Meeting House, in an undulating line. It crosses the county line between Chester and Lancaster a little above St. John's Church, and then runs south and south-west to join the sandstone of the Mine ridge. Following the foot of the Mine ridge on the north side, it leaves the sandstone after a while, and passes about a mile below Strasburg and on the Pequea creek, where some traces of F. II. are visible along the creek, some distance below the main beds of the limestone, not having been denuded. From thence it continues to Willow Street, and is prolonged to the Conestoga, near Wybin's mill. It follows the creek downwards to Hershey's mill, above Safe Harbour, where it crosses and passes round the east and north sides of Turkey hill, reaching the Susquehanna at Wistler's run. A small isolated patch of secondary limestone F. II. has escaped denudation, on the Little Beaver creek, at Jacob Neff's fulling mill, about two miles from Strasburg.

In Bart township, north of the valley limestone, and between the North Valley and Mine Ridge ranges, which consist of sandstone, the gneiss and mica slate occur, and continue, with some slight variations, to the Susquehanna. Turkey Hill is composed of talc and mica slates, which become the prevailing rocks as we approach the river.

Iron ore occurs on Big Beaver creek, in Bart township, near the mill of A. Bare, at the foot of Mine Ridge. It is an argilaceous ore, situated in detritus that has probably been brought down from the neighboring sandstone hill. Much of this sand and loose matter is intermixed with the ore, which has been worked for many years. Iron ore also occurs and is dug near Shenk's tavern, on the Susquehanna, not far from Stoner's ferry. It is an argilaceous ore, and lies near the side of the hill. It is brought to the river to be transported to other places.

Limestone of the Great Valley.

This belt of limestone, which forms the Great Valley, and extends through the western half of Montgomery county through Chester county and Sadsbury and Bart townships, in Lancaster county, commences about a mile and a half south-west of Willow Grove. Tracing it along its southren margin, we find it entering the north corner of Cheltenham township, crossing the Bethlehem turnpike near the Running Pump tavern, a mile below Flourtown, and thence passing to Spring Mill on the Schuylkill, where it crosses the river and follows Gulph creek, through Upper Merion township, into Chester county. This line, after passing the county line, a little less than a mile south of the Baptist Meeting House, follows the foot of the South Valley hill about the same distance north of Glassley and north of the Paoli, to within a couple of furlongs of the Warren tavern, and from thence half a mile south of the Steamboat tavern, and somewhat more to the north of the Indian King. Near Downingstown, it has decreased much in width, being little more than three-fourths of a mile broad. The line passes about two furlongs south of the town. From Downingstown, the foot of the hill indicates the margin of the limestone, which passes rather less than a quarter of a mile below Coatsville on to Freeman's mill, on Buck run; thence to Cloud's *mill, near Phil*ip's tavern, on the Gap and Wilmington turnpike; and to the Octarara creek, near the junction of Cloud's run. In Lancaster county, it follows Cooper's run as far as the dam near the Valley mills, but afterwards continues along the valley a furlong south of the stream. We then trace the same southern margin across the west branch of the Octarara, about a fourth of a mile below Buckman's tavern, and thence to Kunkle's and Eckman's run, at which place the limestone terminates. On Eckman's farm, the line doubles back towards the east, and pursues nearly a straight course, by the Reform Meeting House, to Buckman's tavern; thence running straight to the Octarara, a fourth of a mile above Noble's factory. Its greatest width in Lancaster county is not much more than half a mile. Returning into Chester county, it continues direct to Parkesburg. At Coatsville, it passes one and a half furlong north of the villiage. Two miles east of Coatsville, the belt widens, and passes a fourth of a mile south of East Caln Church. Still expanding, the northern margin passes one-third of a mile north of Downingstown to West Whiteland township line, where it is within a furlong and a half of the Valley turnpike; and thence continues north-east for about three and a half miles. The width of the limestone, taken along the east township line of West Whiteland, is a little more than two miles; and the northern margin is a nearly straight line from thence to the Valley creek, which it crosses half a mile from its junction with the Schuylkill. As the belt passes into Upper Merion, it its overlaid on the north by the red sandstone—a portion of which jutting out in the form of a loop as far as the King of Prussia tavern, conceals that part

of the formation which lies to the north of Reesville. From thence, the northern line continues direct to within half a mile of Norristown, and turning down towards Swedes' Church, crosses the Schuylkill one mile below the bridge. Doubling south a short distance from the river, it forms, in Plymouth township, another loop, and then crosses the Ridge turnpike at the fourteenth mile stone from Philadelphia, and the Germantown turnpike a little more than a quarter of a mile below the fifteenth mile stone. It then passes into Whitemarsh township, crossing the Wissahiccon at Mather's mill, a short distance below Sandy Run, following the run until it reaches the eastern extremity of the belt in Abington township, near Willow Grove.

That portion of the formation which enters Abington township, is more slaty and fractured than that further to the west, and it also contains, apparently, a larger amount of silica. Those portions of the rock which are exposed, or are nearest to the surface, have in many places undergone partial decomposition, and have the appearance of a white calcareous sand. This sandy aspect of the limestone may be observed in all the quarries in the neighborhood of Sandy Run, and also at many other localities. Mostly, however, unless the rock has undergone partial decomposition, the limestone is crystalline and granular; varying in color from blue to white, as a greater or less amount of carbonaceous matter may enter into its composition. Each of these colors is not confined to a particular stratum, but varies repeatedly in the same bed, and, indeed, the area occupied by one particular color is usually very small. The dip throughout the whole formation is remarkably uniform. Near Sandy Run it is towards the south and S. S. E. Quarries and pits have been opened on almost every farm along Sandy Run. One of the largest in this vicinity is on the farm of Mr. Fitzwater, near Fitzwatertown. The limestone is chiefly blue, the dip S. S. E. at an angle of about sixty degrees. The practice of the landholders is to let out the right of working the quarry for a certain period, and the tenant during that time may excavate as much stone as he may require. Many quarries, also, are opened and worked by the proprietor for his individual supply. No record is, therefore, kept, to enable us to ascertain the number of perches annually quarried.

Near the Meeting House, about a mile above Flowertown, a trap dye crosses the Bethlehem turnpike in a north east and south-west direction. It is about two and a half miles long, commencing near the north-west line of Springfield township, and ranging past Bickell's mill on the Wissahiccon to the school house lying half a mile further west. The protrusion of the dyke has not disturbed the adjoining strata to any serious extent. A marble quarry has been opened south of the dyke, near Beck's mill. The rock is granular, and its predominant color is bluish. Crystals of *fluate of lime* occur in this quarry. About half a furlong north of the dyke, there is another quarry on Bickell's farm, in which the beds are somewhat contorted.

At the Episcopal Church, near Seller's tavern, the limestone includes a band of stratified felspathic rock similar to that which is

interposed between it and the gneiss bounding it on the south. This bed is small, but forms a steep hill, which crosses the road diagonally. It has the same range and dip as the limestone including it. It separates into small fragments, often rhomboidal in shape, and is used for repairing the turnpike, being quarried for this purpose.

Another band of somewhat similar felspathic rock occurs on Sandy run, near the margin of the red sandstone. It differs from the last in being less readily decomposed and in containing small crystals of hornblend. It is a very local occurrence, only a few layers of it peeping from beneath the overlapping sandstones. The spot is at a smith shop on Sandy run, a mile east of the turnpike.

On the turnpike opposite Sellerstown, a limestone quarry of some size is wrought, the rock making an excellent lime. An extensive quarry of the same, nearly white, variety of the limestone exists on Mather's farm. There, the beds are crossed by very regular joints, giving the appearance of a stratification, in another direction; the true dip is towards the south.

Traces of *iron ore* occur at several localities in Whitemarsh township, but we meet with no deposites of magnitude until we approach Barren Hill and Spring mill. Near the Germantown turnpike, about a fourth of a mile above the Plymouth Meeting House, are the limestone quarries of Wright and Johnson. Much of the stone in this neighbourhood is beautifully white, though some layers occur having a more or less blueish tint. The weathered surface of many beds is rough and sandy, showing some siliceous matter in the rock. At Marble Hall an extensive quarry of white marble is worked by Mr. Hillman. Some of the beds at this place are remarkably white and uniformily crystalline, while others of simlar texture are bluish or pinkish and some contain small flames of *green talc*. That portion of the quarry from which the best marble is procured is merely a bed, a few yards in thickness dipping S. S. E. at an angle of eighty degrees. About fifty yards further on, another quarry of very similar marble but of a bluer color is wrought. The beds here are not quite so thick. Near the turnpike, on the farm of Mr. Hilder, small beds of *brown iron ore* have been discovered, from which a moderate quantity has been sent to the Schuylkill to be smelted. The ore is rather too siliceous to yield a good iron, with facility. The deposite extends into the adjoining farm, where a small pit has also been dug. Earthy *plumbago* and *black oxide of manganese* occur in both places mixed with much soil and clay. About a fourth of a mile further down the road, two other marble quarries occur in which the beds are nearly perpendicular dipping rather towards the S. S. E. These quarries are not so actively wrought as formerly, when blue marble was in more request. Within a few fields of the quarries, a small body of *iron ore* has been found, resembling in most respects that above referred to. This ore is sandy and not well adapted to make a superior iron. *Iron ore* also occurs on both sides of the Ridge road, near the twelfth mile stone and is dug to a moderate amount. This deposite is rather less sandy than that on the Germantown turnpike. A range of calcareous tal-

cose slates, lies in contact with the felspathic stratum of Barren Hill, extending westward, though not with much regularity to the Schuylkill. They pass into a slaty talcose limestone. In many parts of the general limestone belt, the change from compact to slaty limestone arises from the introduction of talcose matter. The compact, thickly bedded white limestone at Spring mill, seems to be a continuation of the talcose beds in contact with the felspathic rock of Barren Hill. Talc slate occupies a band in the limestone, about two miles north of the Barren Hill church.

Iron ore occurs in the neighborhood of Spring Mill and Conshehoken, on several farms. That belonging to Mr. Kuhnzey, near the township line has been opened, but to a moderate extent. Nearly all the ore in this neighbourhood is more or less siliceous. For its chemical composition see chapter VI. . A quarry of dark blue marble is wrought near the thirteenth mile stone on the Ridge turnpike. In this and another adjoining quarry, the marble is chiefly of the blue variety. The beds dip at a steep angle towards the south, that furnishing the best marble, being sufficiently thick to render the labour of quarrying it less than at some of the quarries already mentioned. A fine natural section along the east bank of the Schuylkill, exposes nearly the whole of this primary limestone belt across its entire breadth. The predominant dip is at an angle of sixty or sixty-five degrees towards the south. From its northern margin for about one mile south, the limestone frequently alternates with thin seams of talc slate and contains thin veins of apparently injected quartz. South of this occur alternating beds of light blue limestone, the change occurring every few yards, until within a mile of Conshehoken, where talc slates begin and extend south to the village. At Conshehoken, a trap dyke crosses the river in a E. N. E. and W. S. W. direction, commencing at the Ridge road at the twelfth milestone and extending westward four miles. The talc slate which crosses the Schuylkill near Horry dam, extends along the Gulf run and gradually thins out. Beyond this to the west, the main body of the limestone lies in contact with the talc slates of the southern primary belt which contain no calcareous matter and which form a moderately elevated ridge, extending across the whole of Chester county, separating the calcareous belt from the mica slate still further south. In that portion of the Limestone Valley which occupies the southren part of Upper Merion township, especially in the immediate vicinity of the Schuylkill, there are numerous and extensive quarries, furnishing a large supply of the rock, a portion of which is transported to Philadelphia, and other places, by the several rail roads and the Schuylkill navigation, a large amount being converted into lime on the spot, designed for the same markets.

A large quarry of the limestone is wrought on the west side of the Schuylkill, two or three miles below Valley Forge, where the rock is tolerably thick bedded and of a light color. The quarried stone is conveyed to the river by a rail road, and thence taken by boats to the various lime kilns. Extensive quarries have also been open-

ed near the Valley Church, where the limestone is very similar to that of the last locality, dipping steeply south, being of a light tint, and furnishing an excellent lime. On the road from Glassley to Valley Forge, near the county line, there is a small bed of slaty, talcose, calcareous rock extending east and west about three furlongs in length towards Valley creek. It constitutes a small hill, over the east end of which the road passes. Near Valley Forge, occurs a stratum of felspathic rock, like that seen at Barren Hill. It is exposed in the creek and occasionally appears emerging from below the sandstone of F. I. at the foot of the North Valley Hill, a little east of the Valley Church. The limestone near the White Horse tavern in East Whiteland township, is occasionally talcose and slaty. Nearer the Steamboat tavern, the more usual granular structure prevails. Throughout all this range, however, the rock makes excellent lime. A little south of the Valley turnpike about three and a half miles east of Downingtown, is the extensive quarry of superior white marble, which has for many years supplied Philadelphia with the beautiful article, employed in so many of its public and private edifices. It is on the farm of Mr. John R. Thomas. The beds on this quarry are slightly contorted. The portion worked for the marble, separates into two bands. The rock occurs in massive beds, chiefly white, with sometimes a bluish tinge, and is quarried with great facility. It has been much used in the construction of the Girard College, and other public buildings, which adorn Philadelphia and the neighbouring towns. It is valued at about three dollars per cubic foot. This marble is converted into a good lime, but its crystalline or granular structure causes it to crumble in the kiln, making it a little difficult to manage. This variety is much esteemed by masons, being sold in Philadelphia under the name of *Fish-egg lime*, a name suggested by its granular structure. In the year 1838, it is estimated that twenty-five thousand nine hundred and ten perches of limestone were quarried in this township. On the farm of Mr. H. B. Jacobs, there is a quarry of dark blue marble, of excellent quality but the demand for this variety has, of late years, declined. At Downingtown the limestone is chiefly of a light color and compact. Two quarries, one, of a compact, the other of a more granular limestone, have been opened on the farm of Mr. Hunt, who, from some experiments which he has made, gives the preference to the lime made from the granular variety. The analysis given in Chapter VI. will show the relative composition of these two species as they exist in this neighbourhood.

The limestone belt is crossed obliquely by a small *trap dyke*, ranging north-east and south-west, which intersects the rail road near Hunt's farm. The width of the formation, near the East Caln Church, is reduced to about three-fourths of a mile. It is somewhat variable, being dependant, probably, upon the angle of the dip; which, however, is pretty constant. At Coatsville, it does not exceed three furlongs. At Bell's quarry, Midway, the rock is light colored. About a mile east of Trueman's mill, we find a small bed of *white clay*, derived from the decomposition of a felspathic stratum lying between

the limestone and the talc slates. In the vicinity of Buck's run and Parkesburg, the limestone becomes darker and more slaty. In passing Cloud's mills into Lancaster county, it gradually declines in thickness, being at Cooper's fulling mill, in Strasburg township, not more than two furlongs wide. At its termination in Bart township, it becomes more than usually sandy, especially near its margin. The main belt seems to terminate on Eckman's run; but another small lenticular belt shows itself a mile and a half further to the west, on the premises of Mr. Bare, where the rock is quarried.

At Gallagherville, a quarry has been opened upon a vein of crystalline white marble, which promises to afford blocks of building material with facility. The bed is narrow, inclining to the south, at a high angle, and will probably increase in value the deeper it is excavated. Iron pyrites occur in this locality.

Throughout the whole valley, the dip of the formation is very nearly constant, varying usually between sixty and seventy degrees, directed towards the south and S. S. E. Mr. W. P. Townsend, of West Chester, estimates that, in 1838, not less than six hundred and eighty-five thousand two hundred and forty-one perches of limestone were quarried within the limits of Chester county, producing, at the average price of sixty cents per perch, 411,144 dollars; but it is probable that this estimate is somewhat too low.

Of the Primary Rocks in the Southern part of York County.

We shall now proceed to describe the primary strata as they occur along the west bank of the Susquehanna river, where they are well exposed by the excavations made along the newly constructed canal. The rocks near the southern State line are chiefly talcose and micaceous slates, occasionally containing arenaceous bands, approaching in structure to a fine grained sandstone. Near Cooper's Point, occur minute but beautiful crystals of *octohedral iron*. At the second lock above the State line, we find a siliceous stratum, fifty feet thick, regularly intersected by cross joints, which is extensively used for the construction of the locks and walls of the canal. Slate Point is a high projecting hill, so named from the roofing slate found in it. This slate splits with tolerable regularity, and affords a durable roofing material, but it is difficult to quarry. The chief portion of the slate now procured on the west side of the river, is taken from the same ridge, two miles distant. The completion of the canal will lend importance to this belt of rock. Talc slate is almost the only rock visible from Muddy creek to M'Call's Ferry, a distance of four miles. The dip here is between fifty and sixty degrees toward the S. S. E. In an extensive excavation along the canal, at one place ninety-two feet in depth, we find the purple *sulphuate of copper*, with a little green and blue *carbonate of copper*, enclosed in irregular veins of *white quartz*. On the south bank of Otter creek, one hundred yards from the river, we come upon York Furnace, near which occurs a thin band of limestone, enclosed in talc slate. It is but two feet thick,

the more compact part appearing to be adapted for agricultural purposes. It does not make a good flux for iron ore, being too magnesian.

At Shank's Ferry, the formation embraces a fine grained gneiss rock. Opposite to this, on the eastern side of the river, a bed of limestone occurs, employed as the flux in York Furnace. The ore smelted at this furnace is from the large mine at Chesnut Hill, near Columbia. Above Turkey Hill, we meet with a nearly perpendicular limestone, in the low grounds between the ridge and the mouth of Cabin Branch run. It is much mixed with slate. This calcareous rock terminates in a wedge shaped point, a few miles west of the river. It is not a part of the primary formation, but a prolongation of the lower, secondary limestone of F. II. of Lancaster county. It is quarried at two or the places near Cabin Branch run. About one and a half miles above Burg's mill, we find a bed of the limestone, having the aspect of a very coarse conglomerate, composed of masses of grey limestone, imbedded in a dark slaty cement. This is about one hundred feet thick. Above the mouth of Cabin Branch run, we pass over a broad belt of dark slate, nearly a mile in width. Near its northern margin was seen a large lump of *iron ore* sticking in the bank, though there seems little probability of finding a valuable deposite of the mineral at this place. Dipping under this slate at an angle of seventy-five degrees to the south-east, is a belt of impure slaty limestone, three hundred feet in thickness. This belongs apparently to the alternating rocks at the junction of F. s. l. and II. Its position is about one mile below Wrightsville. A calcareous and arenaceous rock, referable to F. I. extends along the canal about half a mile, terminating near the first lock below Wrightsville. The limestone at the mouth of Cabin Branch run, the prolongation of that of Lancaster county, extends about three miles west from the river, losing itself a little west of Margaretta Furnace, where it is much interstratified with slate. East of the forge, and lying south of the limestone, occurs a compact siliceous and talcose slate, of much beauty, employed for the locks, &c. on the canal. It is more than two hundred feet thick. Margaretta Furnace, two miles from the river, on the Cabin Branch run, is supplied with *ore* from a deposite in its immediate vicinity, which lies near the northern margin of the slaty limestone, near its junction with the slaty sandstone of F. I. The *analysis*, showing the prevailing composition of this ore, will be found in chapter VI.

A somewhat promising locality of roofing slate exists in the Slate Ridge north of the above limestone. It occurs about two miles south of the York and Wrightsville rail road. In a rather wild and sequestered neighbourhood, among the Barren Hills, thirteen miles south-east from York, we come upon Susan Ann Furnace, not recently in operation, but undergoing repairs. The *iron ore* procured near it was found to make an inferior metal, and was abandoned for a purer variety, obtained about seven miles to the west, at a point seven and a half miles south of York, where the mineral occurs, between seams of disintegrated slate, in nests and loose deposites. It is rather

siliceous, but is said to yield a tolerably good iron. Near the Maryland line, at Essex Hall, on the farm of Mr. Clark, a small deposite of iron ore was worked some years ago. In the fields between this and the State line, are found loose crystals of *red oxide of titanium*. At the State line, five miles west of the river, we find a small ridge of serpentine. It is about a mile long, and lies principally in Maryland. In this belt the mineralogist may obtain fine specimens of *green serpentine*, *actinolite*, *chlorite*, and *asbestos titaniferous iron ore*, and *magnetic iron ore*. A band of chlorite slate, near the northern base of the ridge, contains, in abundance, beautiful *octohedral crystals of iron*. Like the serpentine belts of Chester and Lancaster counties, that above described occurs in lenticular form, in the talcose and chloritic slates. Two miles eastward of this point are the slate quarries already noticed as belonging to the ridge which crosses the river below Peach Bottom. The quantity of roofing slate procured here is considerable. Specimens of *Wavellite* are met with in the quarries.

About a quarter of a mile west of the York and Baltimore rail road, and ten miles south of York, a thin band of impure limestone is imbedded in the slate, and quarried on the farm of Mr. Daniel Diehl. Westward from Diehl's towards Jefferson, it is excavated at several localities, and converted into lime for the fields. At Christian Knull's, east of Jefferson, we meet with indications of iron ore.

The junction of the slate and limestone rocks, F. I. and F. II. is seen on the south of the Pigeon Hills, about four and a half miles north-east from Hanover. One mile south of Hanover, we meet the line of contact between the limestone and slate, ranging north-east and south-west, and passing half a mile south of Littlestown, bringing the margin of the slate to the Maryland line, near Arnold's mill. The limestone belt of the York valley, lying on the north-west of the slate, terminates near this in a wedge shaped point, by the folding round of the overlapping, middle secondary red sandstone, which, after concealing the limestone, encroaches upon the slate.

Section II.

Of Formation I. and II., lying North of the Southern Primary Region in Chester, Lancaster, York, and Adams Counties.

Formation I.—*Sandstone and Slate.*

The extensive slate and sandstone formation which constitutes the lowest member of our Older Secondary or Appalachian rocks, has evidently, at one time, overlapped the southern primary belt in a much wider area than that to which it is at present limited. Some further research is requisite in order to determine with precision its true line of junction with the talcose slates west of the Susquehanna. The slaty rocks of the formation approach often so nearly to the character of the primary schists, as to render it somewhat difficult to delineate

made, and others now in progress in the laboratory of the Survey, establish the fact, that *nearly all* the limestone belts in the south-eastern district of the State, including also those of the Kittatinny Valley, contain bands of magnesian limestone capable of furnishing a hydraulic cement identical in properties with that so extensively manufactured in New York, and on the Potomac, near Sheperdstown.

The town of York is scarcely a mile from the southern border of the limestone; and the excavation for the rail road, a little south of the town, shows a slaty character, denoting its passage into the slate on the south. North of the Codorus, it is extensively quarried and converted into lime. Stet generally light grey or whitish One mile north-west of the town, are extensive quarries, in one of which occurs a beautiful flesh colored marble, but not in beds thick enough to be profitably wrought. On a hill half a mile west of the town, a variegated, silicious and calcareous rock is quarried for a building stone.

That part of the limestone belt south of the Pigeon Hills ranges between their eastern end and the slate ridge to the south, and passing by Spring Forge, advances towards Hanover. South-west of the forge, the belt becomes quite narrow and interrupted by belts of slate; but it may be traced continuously between the slate ridge, or "Barrren Hills," on the south, and Pigeon Hills on the north.

A belt of *iron ore* is traceable along the southern edge of this limestone, near the slate, for several miles. It passes a little south of Hanover and thence towards Littlestown. This ore was mined many years ago, but has long lain neglected, owing to the inferior quality of the iron which it produced, in consequence chiefly, of its containing a considerable portion of the *oxide of manganese*. It occurs in considerable quantity in a small hill two miles south-west of Hanover; from which point to Littlestown, detached lumps of it are visible in the soil for nearly the whole distance.

The red sandstone passing from the west end of the Pigeon Hills, encroaches upon the limestone as it advances south, until near Arnold's mill, at the State line, it overlaps the whole of the formation.

Along the southern base of the Pigeon Hills, in the slates north of the margin of the narrow zone of limestone already traced, we find another belt of *iron ore*, of less length than that on the south side of the limestone. At Moul's five miles north-east from Hanover, the ore was dug about forty years ago. Much of it is scattered about the fields. Huge rocky concretions of ore protrude themselves at the base of a spur of the Pigeon Hills, about three-fourths of a mile to the north-east. The thickness of this deposite of ore is very great, not less perhaps than one hundred feet; but the mineral is extremely siliceous, and unless a new method of working it were devised, would not justify attempts at smelting it. It is possible, however, that by the use of anthracite coal, aided by the hot blast, not only this, but many other siliceous and impure ores, if rich enough in iron, will be found ultimately capable of yielding a tolerably good metal, while with the inadequate heat from charcoal they prove quite refractory.

The northern border of this division of the limestone, after ranging along the southern side of the Pigeon Hills, folds round their south-western termination, and meets the overlying red sandstone on their northern declivity. Extensive limestone quarries, producing a valuable lime, occur on the farm of Mr. Adam Myers, near the end of the hills. A limestone quarry exists on a farm belonging to Mr. James M'Sherry, near Conewago Chapel. Some of the beds yield a fine, compact, light colored variety, promising to be susceptible of a good polish as a marble. It affords a good lime.

The northern division of the limestone is overlapped, as we have said, along the northern base of the Pigeon Hills. It appears, however, a little east of King's tavern, ten miles from York. The course of the southern margin of the overlapping red sandstone from this point is nearly north-east, passing within two and a half miles north-west of York. Between York and the spot at which the limestone disappears at the base of the hills, it is much traversed by small ranges of slate.

The anticlinal ridge, consisting of the white sandstone and overlapping slate of F. II. prolonged from Chicques ridge at the river, ranges along the northern edge from Wrightsville nearly to York, within a mile and a half of which it terminates. The limestone folds round its western end, and extends north-eastward between this ridge and another of siliceous slate, running westward from the Codorus. These uniting, the limestone ceames, in a point, north of the belt of siliceous slate just mentioned, which belongs, apparently, to the upper portion of F. I. We find another small wedge-shaped tract of the limestone crossing the river below Bainbridge, and extending westward about a mile, when it is overlapped by the red sandstone, about a mile north of New Holland. About half a mile west of the river, near its southern margin, we find lumps of *iron ore* in the soil.

Of the Sandstone and Slate of Chicques Ridge, west of the Susquehanna.

The general structure of this ridge is that of a very much compressed or folded anticlinal axis, on the northern side of which the strata lie in an *inverted* attitude, that is to say, the rocks, originally uppermost, are seen dipping apparently beneath others, generally inferior to them in the order of stratification. The consequence is that the limestone of F. II. lying north of the ridge, dips southward, to underlie the rocks of the ridge which consist of F. I. Above the bridge at Wrightsville, the most southern belt of F. I. is a slaty sandstone evidently one of the upper strata. It dips seventy degrees south. Approaching the main axis of the ridge, we meet high perpendicular cliffs consisting of the lower sandstone division of the formation. The color of the rock is whitish, sometimes of a bluish tinge. About a mile below the mouth of Codorus creek to the north of the folded axis, the sandstone is underlaid by a tolerably thick belt of striped slates, this again, by a succession of thick strata of sandstone

and slate, the latter predominating, until we reach the limestone at New Holland. These slates constitute the upper division of F. I. Their general posture is nearly perpendicular, though sometimes they dip slightly north from the axis and sometimes they are *inverted*, or dip towards it. Half a mile above the furnace on Codorus creek, the compact white sandstone dips north sixty degrees. From this to Brillinger's, we see no more of the sandstone, the rock being the upper siliceous slate similar to that at the mouth of the Codorus. The belt of white sandstone terminates westward at a point at about two miles north-east of York, where the Codorus flows round it. The belt of siliceous slate, lying further north, passes westward from the mouth of the Codorus and New Holland, ranging south of Liverpool, until it is covered by the red sandstone at Shultz's, four miles north of York.

Of the Limestone F. II. near the southern base of the South Mountain.

The most north-easterly point at which we observe the limestone, immediately south of the South Mountain, is about a mile and a half north of Petersburg, where a beautiful white and compact variety is opened in a quarry belonging to Mr. James M'Cosh. About half a mile south of this, on the opposite side of a trap ridge, which intersects the formation, occur quarries belonging to Mr. Picking. The rock is here of a light grey color and remarkably soft, being further removed from the modifying influence of the once heated trap rock. Another extensive quarry occurs in the same neighborhood, two miles north west from Petersburg. Much search has been unavailingly made for limestone among the hills near the base of the mountain, ten or twelve miles westward of Petersburg, from whence the lime at present procured is all brought.

The next point at which we notice the limestone, is about two miles north of Fairfield, at Mr. James Blythe's. The rock here is of several shades of color, purplish, greenish and some of it nearly white and crystalline. On the west side of Middle creek, below Myer's mill, it again shows itself but is not quarried. The paucity of the exposures of limestone through this belt of country is due, unquestionably, to the extensive manner in which the lower secondary rocks are overspread by the Middle Secondary red shales and sandstones, overlapping every thing beneath them as far as the base of the hill.

The Rocks of the South Mountain.

The irregular chain of hills termed the South Mountain bounding the Kittatinny or Cumberland valley on the south-east, and crossing the Susquehanna, in their progress to the south-west, consist of a broad belt of nearly parallel ridges, the general direction of whose axes is not exactly coincident with the prevailing course of the mountain, the

latter being nearly from north-east to south-west, while the direction of each individual ridge or axis is more nearly E. N. E. and W.S.W. In consequence of this, the several belts of rock, range somewhat obliquely across the general course of the mountain. Thus, the coarse talcose sandstone of "Green Ridge," from ranging rather on the north-western side of the mountain belt on the State line, constitutes the middle ridge in the neighbourhood of Cold Spring, while a few miles further east it appears on the southern side of the chain.

A section across the rocks on the south of Green Ridge in Adams county, embracing the exposures on the Gettysburg rail road, will serve to show the general structure and composition of these hills.

Passing a *trap dyke* at Biesecker's, west of Gettysburg, the first excavation where the rock of the mountain is exposed shows a compact, grey, siliceous, stratum much traversed by cross joints. Below this occur a few feet of talc slate, under laid by chlorite slate. East of Middle creek is a hard grey siliceous rock and near it a chlorite rock containing specks of *epidote*. A little *iron ore* was found loose in the soil here. We next pass alternations of the grey siliceous rock and greenish slate and afterwards a deep excavation in a hard grey siliceous stratum, containing specks of *white felspar*. This includes a bed of beautiful veined grey rock. Passing the viaduct, one hundred feet of grey slate is seen graduating into sandstone. About half a mile from the end of Jack's mountain, a hill nearly seven hundred feet high, the bluish slate is interstratified with sandstone. Further to the south-west, the sandstone becomes less talcose and more siliceous. Without any material variation, this extends to the contemplated tunnel near the western end of Jack's mountain, embracing probably a thickness of one thousand feet of this limestone. Near another projected tunnel in a ridge uniting with the north-west side of the mountain there is a hard epidotic and quartzose rock of considerable thickness and near it a greenish slate. On the southern side of the next ridge, is a thick belt of a similar green slate, including bands of grey slate spotted with *epidote*. About a mile and a half south-east of the intended summit of the road, is a cutting in dark grey slate, then occur greenish slate and a purplish grey siliceous rock, spotted with some crystallized epidote. Further on we find an epidote rock containing asbestos fron which to the end of the cutting occurs a dark grey siliceous rock. Near the summit a flat swamp occupies a considerable area on the top of the mountain. Near Red run, a branch of Antietam creek, a compact siliceous sandstone shows itself, similar to that along the south side of Jack's mountain. This terminates the excavation on the rail road.

On the road from Fairfield to the Emmetsburg and Waynesburg turnpike near Miney run, diggings to some extent were undertaken, several years since in search of *copper ore*. Nothing is visible in the materials dug out, calculated to inspire a hope of finding a productive copper vein in this locality. In a small ridge north of Jack's mountain, several openings from copper ore were commenced by Mr. Thomson, and a small quantity of ore obtained and a furnace built for

smelting it. These works are now abandoned. The metal occurs in the form of green and blue carbonate with a little native copper. The ore seems not to have been abundant.

The rock immediately north-west of Green Ridge between the State line and the Gettysburg and Chambersburg turnpike is a sandstone evidently F. I. no other rock appearing between Hughes's rolling mill on Cold Spring creek and Montalto furnace, on the south-west branch of Antietam. Further towards the north-east this sandstone constitutes only the south-west part of the mountain. At Caledonia furnace, on the Chambersburg turnpike, it is confined to the two narrow ridges lying west of the furnace, while the whole of the rocks south-east of this, as far as Green Ridge consist of the red and grey siliceous strata with their included greenish slates.

Crossing the mountain between Caledonia Furnace and Cold Spring, a distance of seven miles, in a S. S. E. direction, no vestige of the white arenaceous sandstone of F. I. was seen, until the foot of Green Ridge, at Cold Spring, was reached. The section displays rocks precisely similar to those on the east side of the mountain, on the rail road at Maria Furnace and at Holms's creek, showing every where marks of alteration by igneous action. In the ridge west of Caledonia Furnace, occurs a talcose sandstone; and a fourth of a mile south of the furnace, a highly altered, jaspery slate. Half a mile south of the furnace, we meet a grey, spotted, siliceous rock, evidently an altered sandstone; two miles south of the furnace, a grey, altered, siliceous rock, with dark blotches; and two miles north of Cold Spring, a greenish slate, spotted with epidote, and charged with much white quartz. One mile north of the same place, a reddish slate, speckled white, occurs; and half a mile nearer Cold Spring, is a red, jaspery, altered rock; all belonging, probably, to the thick system of slates composing the upper member of F. I., but greatly modified in texture by the intrusion of quartz and other igneous matter. Throughout this section, the strata dip invariably to the south-east. Though no anticlinal axis is visible, there is convincing evidence that the rocks have been upheaved along such an axis, and folded together, so as to make those on the north-west dip in an *inverted* altitude to the south-east—a feature very common throughout the whole range.

The mountain gap of the Gettysburg and Chambersburg turnpike divides the altered slaty rocks on the south from the unaltered sandstone on the north, until in our progress eastward we reach Newman's near the summit, east of which the altered rocks cross the road, to range north-eastward along the southern ridges of the mountain. The sandstone ridges which constitute the north-western spurs of the mountain, near Caledonia Furnace, jutting towards Green village and Shippensburg, ranging north-eastward, become the main body of the mountain, the *altered* rocks lying on the southern side. The same bed of altered rocks which lies between Caledonia Furnace and Cold Spring, and which crosses the turnpike south-east of Newman's, is

seen on the southern side of the mountain, crossing one of the head waters of Conewago creek.

Crossing the mountain by another section further to the north-east, we find the following order of things. Beginning at Cumberland Furnace, and passing to the head waters of Opossum creek, the north-western ridges of the mountain, near Cumberland Furnace, consist entirely of the sandstone of F. I. In the ridge north of Pine Grove, the rock is a more talcose sandstone, belonging probably to a higher part of the formation. Large veins of white quartz are here abundant. A whitish talcose slate rests conformably upon the talcose sandstone, dipping with it to the south-east. This latter rock forms an admirable material for the in-walls of a furnace, and is used in that at Pine Grove. Immediately south of Mountain creek, near the furnace, occurs a thin interposed belt of limestone, used as a flux, and also taken across the mountain, into Adams county, for lime for the fields. This rock contains disseminated crystals of *fluate of lime*.

Associated with this limestone, is a valuable deposite of *iron ore*, which has supplied the furnace here for a long time. It is of the kind usually found in our limestone soils, being technically the *brown hydrated proxide*, having a variety of structures. The *analyses* given in Chapter VI. displays the composition of one variety of the ore of this mine.

The limestone is evidently one of the interpolated beds common in the upper division of F. I. Passing the low ridge containing the limestone, we encounter a bold mountain of somewhat talcose sandstone, two miles in breadth, containing probably an axis of elevation with the rocks on its northern side *inverted*. On the southern flank of this ridge occurs a belt of altered siliceous rock, including a narrow band of talcose slate; and south of this, a zone of green altered slates, charged with epidote and quartz; and overlying this again, another belt, of a more siliceous altered slate. It is interesting to observe the importance which a single belt of limestone will give to a locality. It has here given rise to a rich deposite of *iron ore*, rendering productive a most beautiful and sequestered spot in a chain of hills, elsewhere remarkable for their forbidding features and sterile soil. The calcareous rock is only developed, to any extent, near the furnace, though it is said to be visible at Dull's saw-mill three miles higher up Mountain creek.

Another section across the mountain, still more to the north-east, extends from south to north along the Baltimore and Carlisle turnpike. The first important stratum of the hills is the usual grey siliceous altered rock so common along their southern side. North of this, about three miles from Petersburg, occurs the dark green slate, with its epidote and white intrusive quartz. Succeeding this, is an extremely compact, siliceous altered slate; and beyond this, a reddish grey rock, of the same series, containing specks of reddish felspar and small veins of epidote; and near this, the fissile talcose rock, several times mentioned before. North of these, we pass a tract of low ground,

and then a high, rough ridge of sandstone; ascending which, we come to Mountain creek, at Holly Furnace—not now in operation. Beyond this to the north, is another bold ridge, the northernmost of the chain, consisting also of the white sandstone of the lower division of F. I., which here resembles closely the same rock as it occurs in Chicques ridge, on the Susquehanna. The beds here have a steep southern dip, of about seventy degrees. This dip is evidently, however, an *inverted* one, as these are the *lower* rocks of the formation, and lie north of the proper position for a folded or anticlinal axis. Between the northern base of this ridge and the margin of F. II., the limestone of the Cumberland Valley, a deep deposite of diluvial matter hides from our view nearly the whole of the slaty or upper division of F. I.; which, in consequence of its easy denudation, is commonly found in the valley at the foot of the mountain, thus covered by transported matter.

The north-eastern termination of the mountain, near Dillsburg, consists entirely of the lower sandstone, the altered slaty belt on the southern side having disappeared between the Petersburg and Carlisle turnpike and the end of the mountain, in consequence of the subsiding of the axis of elevation. It ends in two principal ridges. In a rough valley between these, occurs a yellow porous sandstone, often indicative of *iron ore*, some of which was found on the surface near the end of the southern ridge. A little north of Dillsburg, the limestone of the Cumberland Valley folds round the eastern end of the mountain, and appears on Dogwood run, south of Yellow Breeches creek, where it is covered by the overlapping rocks of the middle secondary series, consisting here of the calcareous pudding-stone, or Potomac marble, and altered red shale and red sandstone.

CHAPTER II.

Sketch of the operations of the Survey in the North-eastern Appalachian district, or that, lying between the South mountain and the Allegheny mountain, and between the Delaware and Susquehanna rivers, embracing the Anthracite coal fields.

The investigations in this district during the past year consisted of numerous detailed examinations in the southern coal basin, resulting in the developement of new and clearer views respecting the position of the coal in many important tracts. Many valuable local facts were ascertained, tending to give a truer insight into the structure and re-

sources of this great coal field. By an extensive and laborious comparison of these, we have been enabled to delineate the outcrop of the principal important coal seams, upon our enlarged geological maps of the region, and to represent, as far as ascertainable, the relations of the beds beneath the surface, in an extensive series of sectional drawings. These sections, compiled from measurements as exact as could be made or procured, will furnish in conjunction with the maps when completed, a picture of the position of the coal throughout the several basins: rendering plain, many intricate features which no mere description, unaided by them, could make intelligible. The total number of sections at present drawn, displaying the situation of the coal, amounts to about one hundred and twenty. I am happy to state that the map intended to exhibit, on a large scale the topographical features of the several coal basins, and as nearly as practicable the range of the coal, is in a condition of considerable forwardness, though from the excessive complexity and truly wide extent of our anthracite region, much research will yet be necessary in order to complete it.

Having in my last annual report described with sufficient precision the approximate boundaries of the coal measures, in the numerous lesser basins into which the whole region is subdivided by a series of nearly parallel lines of elevation, and conceiving it injudicious, nay, wholly impracticable to enter at this time upon any local and partial details, which if published, could not be intelligible without the map and drawings, and which in their most compressed form would swell this report to more than twice its present bulk, I shall postpone a particular description of the district and refer the reader to my final and general report, which I confidently hope to finish in about two seasons more.

While carrying out the train of research begun during a previous season, in the several anthracite coal fields, attention was also especially directed to a subject which at present claims a high share of importance in connection with the resources of this portion of Pennsylvania. The application of anthracite coal in the process of smelting iron, first made in Wales, and recently introduced with entire success at Pottsville, by an enterprising citizen of the State, has called forth much inquiry as to the productiveness of our anthracite region in regard to ore.

I have therefore spared no pains to collect information bearing upon this important question, visiting and causing to be visited, particularly in the Pottsville region, every locality promising to be valuable in regard either to the quality or quantity of the mineral. Out of a variety of specimens collected, as great a number have been analized as the limited time allowed for the preparation of an annual report would permit. These have been selected with a view to show particularly the prevailing quality and average richness of the ores of the region generally. Especial care has been therefore taken to submit to chemical examination, such specimens only, as represent the average character of their respective beds, choosing those freshly

opened in the mines or in some deep excavation, and rejecting as far as possible, samples gathered from the outcrop or found loose on the surface, as these invariably contain *two high* a percentage of iron, to prove a fair criterion. The results of the chemical examination of these ores will be found detailed in chapter VI. of the present report. While making these explorations, information on the subject was freely imparted to the proprietors of the lands, or mines, respecting their own deposites and a number of chemical analysis of their ores were presented to the owners with a view to guide them in their search.

The same views of utility which induced us to direct a share of our attention to the geological and chemical relations of the iron ore in the anthracite coal region have led us to explore both recently, and in previous seasons the district in search of limestone, valuable in many of the arts, but indispensable in that of making iron. Careful analysis have therefore been made of all the more promising calcareous bands appertaining either to the coal measures themselves, or to the lower formations situated outside of their boundaries. We have yet found no calcareous bed within the coal fields with a sufficient proportion of carbonate of lime to justify its use as a flux for iron. The mottled calcareous layers which occasionally occur in the upper beds of red shale F. XI. on the side adjacent to the conglomerate that underlies the coal, have also been subjected to chemical trial, the results of which made upon the purest of these yet found will be included in the final chapter. I have also recorded an analysis of the limestone F. VI. which ranges through the Orwigsburg valley south of the Pottsville coal basin, deeming it the nearest belt to the coal measures, pure enough to be employed as a flux. With the same view an analysis is given of the limestone F. II. of the region south of the Blue mountain, the variety examined being procured adjacent to the Schuylkill, about nine miles north of Reading, and being the kind now successfully employed in the blast furnace at Hamburg.

The amount of ore in each of the several coal basins of the anthracite region being evidently very great, and sufficiently ample should the quality be found proportionately good to contribute materially towards the supply of the numerous large blast furnaces likely to be erected in and around these coal fields at no distant day; it is not necessary in the present early state of researches on this subject to attempt a discription of the localities already developed. Besides being too burthensome for an annual report not furnished with the drawings necessary to explain them, these particulars respecting the ore would be of only very transient interest, inasmuch as every month is bringing to light many new deposites and altering the aspect of those already opened. I have thought it judicious, therefore, to submit at present only the chemical part of our examinations, as detailing the species of information which is at this time of more general and immediately practical interest. It was my intention to offer more than twice the present number of analysis of ores found in the anthracite coal mea-

sures, but the accidental miscarriage of a large box of specimens collected at a number of localities, has interfered with the design.

At this period when to all appearance, anthracite is about being extensively applied to the manufacture of iron, it is important that the composition of this invaluable combustible should be adverted to, for success in using it must much depend upon attention to the peculiar properties which distinguish it from other varieties of fuel. I have therefore deemed it desirable to accompany the analysis of the ores of the region with the results of similar experiments upon the coal, placing in the same chapter for the purpose of comparison, the chemical constitution of a number of coals from other districts in the state.

After prosecuting, during the early half of the season our examinations among the coal measures, and obtaining as much local information as practicable concerning the localities of iron ore, developed in the various recent excavations or in natural exposures, a portion of our attention was given to the geology of the valley north of the Blue or Kittatinny mountain. This belt of country was minutely explored from a point some distance east of the Little Schuylkill, westward to the Swatara, and a detailed map of its topography exhibiting the true position and range of its numerous and somewhat intricately distributed formations was at the same time constructed. This map will be extended hereafter to embrace the whole belt of country lying north of the Blue mountain, from the Delaware to the Susquehanna, and be connected if our time will permit with the general map of the coal region.

CHAPTER III.

Sketch of the Geology of those parts of the Third or South-Western Appalachian District, examined during the last year, embracing the counties of Cumberland, Franklin, Mifflin and Huntingdon, a portion of Bedford, with a part of Union, and a small part of Centre.

Turning, now, to the district lying south-west of the Susquehanna, embraced between the South Mountain and the base of the Allegheny Mountain, I shall, in presenting a general sketch of the geological structure and resources of the portions last explored, commence with that portion of the Great Kittatinny Valley, which includes the counties of Cumberland and Franklin, and which in this State is commonly called the Cumberland Valley.

SECTION I.

Of the Rocks of the Cumberland Valley, embracing Formations II. and III., with their associated Iron Ores, &c.

In describing the formations of this valley, we shall commence, as usual, with the south-eastern belt, taking it up at its north-eastern end, and tracing it southwardly. This belt is the great limestone tract of the south-eastern half of Cumberland and Franklin counties, our account of which commences at the Susquehanna river.

Limestone F. II. in the South-Eastern half of Cumberland and Franklin Counties.

Resuming our section along the south-western bank of the Susquehanna, we find the southern margin of the limestone overlapped by the red shales of the *middle secondary series*, about two miles below New Cumberland, at the mouth of the Yellow Breeches creek, the limestone rising in a moderately elevated cliff, near the river. Near its contact, it has derived a reddish tinge from the overlying red shale; but a little further north, in Musser's quarry, it loses this strain, some layers presenting the aspect of a fine white marble, which, if thick enough to work, would be a valuable rock. The prevailing dip of the limestone here is towards the S. S. E., at an inclination of forty-five degrees. Near the mouth of the creek, the limestone contains a narrow belt of slate, visible occasionally for several miles up the stream, and extending, indeed, the whole way to Maryland, along the southern border of the formation. Above New Cumberland, the limestone is discernable along the water's edge, preserving its usual character and dip. About a mile above, the dip diminishes to thirty degrees south, and gradually grows less, until a little more than a mile below the rail road bridge, at Harrisburg, the strata become horizontal, indicating this as the position of a flat anticlinal axis. North of this, for about a fourth of a mile, they incline northward, at an angle not exceeding twenty degrees. We then find a flat synclinal axis, beyond which, for three-quarters of a mile, to the bridge, the steeper southern dip is resumed, gradually increasing, until at the bridge it is about fifty-five degrees. The steep southern dip continues to the boundary of the limestone and slate, or F. III., which is seen in the ravine at the bridge, along which the rail road passes. The slate here, dipping to the south or under the limestone, is evidently inverted by a folding of the rocks in the limestone belt, somewhere between this point and the synclinal axis above mentioned. The natural or original position of the great slate formation of the Kittatinny valley, is *above* the limestone.

From this point of junction near the bridge, the line dividing the two formations, ranges nearly westward to the most southern bend of the Conedogwinit creek; following thence the *general* course of that stream, the southern bends of which reach but do not penetrate the

limestone, while its northern meanderings lie all in the slate. The limestone, towards its northern margin, contains thin belts of the slate, similar to that noticed as ranging near its southern side. Near Newville, the boundary leaves the course of the Conedogwinit, to bear somewhat more southwardly. It here makes a double turn, taking a zigzag course in consequence of an irregular anticlinal axis near Newville, which elevates the limestone in a long projecting point, penetrating the slate north-westwardly. Resuming its regular course, it passes south-west from Newville, leaving Shippensburg three miles to its south-east, and then deflecting still more towards the south, it passes a little west of Green village, and reaches the Conecocheague north of Chambersburg. It follows this stream past the town, and after pursuing it about four miles, stretches away in a S. S. W. direction to Greencastle, and thence on to the Maryland line, which it intersects about a mile east of the Conecocheague.

The southern margin of the limestone leaving the Susquehanna two miles below New Cumberland, runs first north-westward, and then westward for several miles, leaving a narrow belt of the rock on the south side of Yellow Breeches creek. The overlapping red shale crossing the creek about two miles north of Lisburn, follows its border to Bryson's, west of Lisburn, where the red shale leaves the limestone, the formation beyond this point being bounded on the south by the rocks of F. I. Making the general course of the creek its margin, the limestone passes by the south side of the stream, at Williams's mill, about three miles north of Dillsburg, and extends some distance along Dogwood run, folding round the end of the South Mountain.

Further towards the south-west, the edge of the limestone lies near the north-western base of the mountain, though it is frequently concealed by a covering of diluvium. In some places, owing to a fault or sudden folding together of the slate of F. I., immediately at the base of the mountain, the limestone approaches the sandstone, and indeed in some of the ore banks, situated low down on its declivity, limestone shows itself beneath the ore. In these instances, however, it is probably not the main body of the formation, but a narrow belt in the slates of F. I. The limestone, generally, is much interstratified with greenish and reddish slate along the base of the mountain.

Having thus defined, with sufficient accuracy, the two boundaries of this broad tract of the limestone, I shall next notice some of the details connected with the formation most deserving of description in this place, leaving the minute and systematic delineation of the whole for the pages of my final report. Proceeding westward from the Susquehanna, we meet with a deposite of good iron ore, about two and a half miles from the Harrisburg bridge, on the farm of W. R. Gorgas. The ore is imbedded in the ferruginous soil which overlies the limestone. It occurs in bunches and irregular veins, the general direction and dip of which coincide somewhat with those of the underlying limestone. It is conveyed by the rail road to the river, and thence by the canal to the furnaces above Harrisburg. It is the usual

brown ore, and is of a cellular structure. The analysis in chapter VI. will show its average composition.

A trap dyke crosses the Yellow Breeches about two miles north of Lisburn, altering, more or less, the adjacent limestone. In the vicinity of Sheperdstown, three miles south of Mechanicsburg, the limestone encloses a considerable tract of slate, rather more than half a mile in breadth. This slate is probably a portion of F. III., folded in between the limestone in a compressed synclinal axis. About a fourth of a mile north-west of Sheperdstown, iron ore, apparently of good quality, has recently been obtained. It has not thus far proved abundant, though little has been done towards developing it. At the Carlisle Iron Works, six miles S. S. E. from Carlisle, a trap dyke, issuing from the mountain, crosses the Yellow Breeches creek immediately at the furnace, and extends north twenty degrees east, entirely across the valley, meeting the base of the Kittatinny or North mountain about two miles east of Sterrett's Gap. It forms a sharp, very narrow, rocky ridge, from ten to seventy feet high—a useful natural boundary employed to designate the township lines. The limestone is considerably affected by it in its texture and color, though not much disturbed in its prevailing south-eastern dip. In a quarry near the furnace, a little removed from the trap, the rock has the aspect of fine grained, whitish, and dove colored marble. This trap dyke, and the contiguous beds of the limestone, are well seen in the cutting on the Harrisburg and Chambersburg rail road, where the dyke is about sixty feet wide. Another lesser trap dyke penetrates the limestone a little westward of the former.

The ore which supplies the Carlisle Iron Works is obtained at several points. One variety, denominated "mountain ore," occurs along the northern slope or base of the first sandstone ridges, near the junction of the limestone. Another variety, known as limestone or *pipe ore*, belongs to the ferruginous soils overlying the limestone itself. The iron obtained from the mountain ore is generally "cold, short," hard and brittle; while that derived from the limestone ore is softer, tougher, and more tenacious. The mountain ore is in some furnaces employed alone for the manufacture of foundry pigs and castings, but a mixture of the two kinds is generally deemed necessary for the production of good cast iron for forging. One principal reason of this is, that in the mountain ore derived originally from the strata of F. I., the oxide of iron is associated with a larger proportion of the oxide of manganese, and other deleterious constituents, than generally accompany it in the ores of F. II., originating from a different source. Both of these varieties belong to the general species called by mineralogists, brown hydrated iron ore, though they assume a considerable diversity of aspect and structure, arising from their greater or less degrees of richness and purity, and the manner of their concretion.

The mountain ore, obtained a mile and a half south-west of the Carlisle works, is of several descriptions. In the upper portion of the deposite, much of it is compact, passing under the name of "hard

ore." The "honey-comb ore," lying beneath this, or imbedded between it, is a softer and more porous variety, more readily reduced in the furnace. Half a mile south from the furnace, a small body of a somewhat different ore has been met with.

The "limestone ore" employed at this furnace, is obtained from a belt about two miles N. N. W. from the works, where ore has been dug, in different places, for several years. The present supply is chiefly from a deposite about eight feet thick, reached by a shaft from sixteen to twenty-five feet deep, Much of it belongs to the fine variety denominated "pipe ore," consisting of a congeries of parallel stalactitic tubes or stems, from whence it derives its name. One part of this ore is mixed with two parts of mountain ore in the manufacture of forge pigs. For the chemical composition of these several ores, see chapter VI.

The limestone employed as a flux at this furnace is selected with a view to facility in procuring it, more than from a regard to its purity; some of the belts lying further north would be better adapted. Between the deposites of limestone ore above mentioned and Carlisle, ore is found in several places; an extensive digging, now abandoned, occurring near the Hanover road. Half a mile south of this, on a farm belonging to Mr. Holmes, a very good looking ore occurs, which has been more recently mined. Between this and Carlisle, other excavations exist, from whence the ore is conveyed across the North mountain to a furnace south of Landisburg, where it is mixed with ores of that neighbourhood.

In the neighbourhood of Carlisle, occurs much good limestone; both the ordinary kind, adapted for making lime, and the magnesian variety, suitable for the manufacture of *hydraulic cement.*

About four miles westward from Carlise, near the State road occurs a neglected excavation where iron ore to some extent has been procured. About four and a half miles south of the town near the turnpike, is a deposite of apparently good ore formerly wrought to some extent, to supply Holly furnace not now in operation. On the Walnut Bottom road about five miles south-west from Carlisle ore, is abundant on the surface of a little hill. Southward of this at Peffer's, between the foot of the mountain and the creek, ore was formerly obtained for Holly furnace, and more recently for Cumberland furnace. See Analysis, chapter VI. Though not far from the sandstone of the mountain, some of it is of the variety called pipe ore, characteristic of the limestone formation, parts of it however, are manganesian. Along the low ground, near the foot of the mountain, ore is abundant on the surface for a considerable distance westward.

Cumberland furnace, the property of General Thomas C. Miller, not in blast at the time of our explorations in the vicinity, has been smelting chiefly the ore obtained near the base of the sandstone ridge of the mountain about three miles south-west from the furnace. This ore appears to lie in bands, and large bunches or nests in the loose soil near the bottom of the declivity of the mountain. The mine

chiefly wrought at present, is an irregular excavation, from thirty to forty feet deep, in the sides of which, the ore is scattered in lumps throughout a large extent of the deposite, but is best, and most abundant nearest the bottom. The ore from this bank is mixed with an ore from the limestone tract obtained a mile and a half north of the furnace. For an analysis of each of these ores see chapter VI.

Iron ore occurs on the surface about seven miles west of Carlisle on the farm of Mr. William Kerr, in considerable quantity. For the composition of this ore see chapter VI.

Near the Big Pond at the head of Yellow Breeches creek, we come upon Pond Furnace, owned by Mr. John Moore, worked by the hot blast and making foundry iron. The ore smelted at this furnace, is procured from F. I. on a low spur of the mountain, south-west of the Pond. The old excavation on the eastern side of the hill have lately been left and another deposite opened on the western side by a shaft which shows several feet of ore about twenty feet from the surface. The limestone employed as a flux in Pond furnace, is collected from the surface fragments of the neighbourhood and is therefore of every diversity of character. For an analysis of the ore see chapter VI.

Mary Ann furnace, the property of Messrs. Whitehill and Ellis, lies about three miles west of the Pond. Near it is Augusta furnace, belonging to the same firm. The latter is not in operation. These furnaces are situated close at the foot of the mountain, about three miles south-east of Shippensburg. Mary Ann furnace, now in blast is supplied with ore from two banks, one lately opened, called the "Helm bank," three miles north-east of the furnace, and another called the "Clippinger bank," two miles towards the north-west. The Helm bank ore overlies that part of the limestone which is much interstratified with slate, being near its margin. The ore is apparently about two feet thick, dipping steeply to the north-east, but varying much in quantity in different parts of the excavation. The Clippinger bank yields an ore of the very best description, much of it being stalactitic, or of the kind called pipe ore. The analysis to be found in chapter VI. will display the prevailing composition of the ores of both these banks.

The above Clippinger ore occurs in irregular nests in the interstices of the limestone rock, surrounded by a very tenacious reddish clay. The quantity fluctuates much in different spots and the water incommodes more or less the deep diggings. These circumstances attend nearly all the deposites of the limestone ore in the valley. Where the ore occupies the interstices between the beds of limestone, it is almost invariably pure and of the pipe ore kind, though the quantity in these situations is apt to be precarious. The mountain ore obtained near the junction of the limestone and the sandstone of the mountain and therefore, generally along the slaty or upper division of F. I. is procured with greater certainty, but is frequently quite unfit for making forge pigs without an admixture of the purer ore of the limestone, being used by itself only for foundry iron. The flux used in

Mary Ann furnace is a limestone procured in the vicinity of the Clippinger bank.

Southampton furnace is situated about three miles further to the south-west, or four miles south of Shippensburg. It belongs to Mr. Charles Wharton, of Philadelphia. The two furnaces in blast here are supplied with ore from these different banks. One called the "Hill bank," lying about three hundred yards west of the upper furnace, contains the mountain ore in its usual varieties. That in the upper part of the mine is hard and cold short while a honey-comb ore lying beneath it is of much better quality. The ore of this bank supplies the upper furnace which uses the hot blast and makes foundry iron and castings.

The lower furnace is furnished with ore from a mine at Kressler's, three-fourths of a mile to the north-west, and also from the "Rail Road bank," lying in the limestone formation, four miles west of the furnace. The ore at Kressler's has been extensively wrought for some years. It occurs in nests and irregular layers in the soil and rotten slate, which have a range and dip nearly coinciding with the direction of the underlying strata. This ore is esteemed well adapted for making good bar iron, but is less productive in quantity than some others in the neighbourhood. Much loose ore is visible on the surface north of the present excavation. The "Rail Road bank" formerly yielded a valuable supply of good ore, but the encroachment of the water and probably a reduction in the quantity of ore, have caused it of late to be less vigorously wrought. The ore exists rather in bunches or nests than in regular layers and is hence very variable as to quantity. A small ridge of limestone bounds the ore immediately on the north. The lower furnace, smelting these ores, makes forge pigs for bar iron, and uses the blast cold. For the *analyses* of these several ores consult chapter VI.

Proceeding northward to the neighbourhood of Shippensburg, a moderate amount of excellent ore has been procured in a spot called the "Pilgrim bank," near the northern margin of the limestone, three miles and a half from the town. A good ore was formerly obtained on the farm of Mr. Hamills, a mile and a half south-east from the town. Ore was also procured about a mile and a half west of Shippensburg, at the old Roxburg bank. It was the *stalactitic* or *pipe ore* and made a bar iron which was much esteemed for its soft and tough qualities, but as usual with ore of this description the quantity was limited. For *analyses* see chapter VI.

About two miles south-east from Greenvillage, and half a mile north of the rail road, a deposite of beautiful *pipe ore* of excellent quality, is wrought for the supply of Caledonia furnace, to which it is conveyed a distance of eight miles in wagons. It produces a good iron and with great facility, agreeing in these respects with the pipe ore generally. It occurs in bunches, which together form an irregular layer conforming with the direction of the adjacent limestone. Its position is between two little ridges of the limestone, one of which immediately bounds it on the north. It is deeply covered with earth

and must be somewhat expensive to procure. For *analyses* see chapter VI.

Caledonia furnace, the property of Messrs. Stevens and Paxton, is situated on the Gettysburg and Chambersburg turnpike, ten miles from the latter place. It is supplied with ore from several deposites, besides the Greenvillage bank already noticed. A belt of ore ground extends apparently for several miles near the line of contact of the limestone of the valley and the sandstone of the ridges, which jut forward in advance of the main body of the mountain. On this line of ore, coinciding probably with the position of the crushed slates which intervene between the limestone and the sandstone, the Pond banks occur about three miles from Caledonia works. They consist of extensive diggings in which the ore is met with at various depths in nests and irregular layers included in a ferruginous soil, much of it has a hollow reniform structure. About three hundred yards south of this, a bed of ore was formerly wrought for the supply of Montalto furnace. It overlies the sandstone, and yields a metal of very indifferent quality. The flux employed in Caledonia furnace is procured a little north of the Pond diggings.

Another excavation furnishing ore for the same furnace occurs three miles further to the south-west, at Hiefner's. This bank situated further from the mountain than the former, yields an open and crumbly ore which smelts with facility but produces a somewhat cold short iron. The chemical composition of these ores will be found among the analysis in chapter VI.

In one of the openings at Hiefner's, an impure limestone was encountered thirty feet from the surface. A little eastward of the openings, some pipe ore occurs in the soil, for an analysis of which see chapter VI.

Another belt of ore ground seems to exist on the summit of a little ridge of limestone north of the former excavations. This ore is different in quality from the other and promises to be abundant twenty feet below the surface. The ridge extending southwestward, the ore seems to continue along it, and about three fourths of a mile from the Hiefner bank, occupies the surface in an abundance seldom seen. It has been partially opened here, but making a highly cold short iron has been abandoned. These deposites of ore seem to range nearly along the line of contact of the limestone, and a narrow interposed belt of siliceous slate and sandstone.

About a fourth of a mile south-east of Beattie's on the turnpike, occurs a dark colored limestone, an unsuccessful trial of which as a flux was made in the furnace. The *analyses* showing its composition will be seen in chapter VI.

Iron ore, of very inferior quality, occurs between two ridges of sandstone three miles N. N. E. of Caledonia Furnace; affording another evidence of the impure nature of the ores derived from the rocks of the South mountain, when compared with those which occur in the limestone of the belt immediately north-west of it.

Montalto Furnace, the property of Mr. Hughes, is situated on a branch of the Antietam creek, about seven miles north-east from Waynesburg, and near the foot of the outer sandstone ridge of the mountain. Though ore appears upon the surface, in more or less abundance, the whole way along the north-west base of the mountain from Ege's Carlisle works to this place, yet no where does it occur in such profusion as between the Caledonia diggings at the pond and a point two or three miles south-west of Montalto. This furnace is supplied from extensive excavations lying about a fourth of a mile north-east of it, on the declivity of the first sandstone ridge. The ore occurs, as in other similiarly situated mines, in the loose soil of the mountain side, in nests and irregular layers, varying greatly in their dimensions: but the whole deposite seems to be of prodigious magnitude. It is believed by the miners, that the body of ore in which they are now working is not less than forty feet thick and sixty or seventy yards wide,—including, of course, the feruginous earth between the bunches and veins or ore. The lower portion of the ore is the purest. This ore, so abundant in quantity, does not, however, yield a high per centage of iron. The furnace, seems to be a successful one, producing annually about eight hundred tons of metal, in the shape of castings and forge pigs for the use of two forges and a rolling mill, situated on the east branch of Antietam creek, five miles below the Cold Spring. The compositton of these two ores is recorded in chapter VI.

In one of the deeper diggings of Montalto, a band of limestone has been reached, being a layer probably in the slates of F. I. It is interesting to observe the connection between limestone rocks and large deposites of iron ore of the variety, called *brown hydrated per-oxide.*

South-westward from Montalto, much ore strews the surface along the north-western side of the mountain. In the neighbourhood of Tomstown, it occurs in large blocks, but is very silicious, being associated with fragments of the yellow silicious rock already alluded to as frequently accompanying the iron ore along the mountain.

The limestone folding round the southern end of this mountain ridge, extends some distance up the little valley of the Cold Spring branch, appearing on the north side of Green Ridge below the rolling mill. *Iron ore,* in moderate quantity, but of inferior quality, has been dug to some extent on the north-west side of the stream. The *analyses* exhibiting its chemical nature may be seen in chapter VI.

A considerable amount of ore is visible in the soil on the farm of Mr. Middauer, three miles north-east from Waynesburg. It promises to be rather too silicious to make a superior iron. For *analyses* see chapter VI.

On the southern part of the same farm, and also on another adjoining one, loose masses of tolerably pure white sulphate of baryta occur. It probably occupies a position between narrow belts of limestone and slaty sandstone, which traverse the hills of this neighbourhood.

Proceeding from the foot of the mountain towards Waynesburg, after leaving the low grounds, we first meet with slaty limestone, alternating for some distance with slate, until we reach the second ridge, three miles south-east from Waynesburg, where a band of white limestone crosses our section. This latter rock is quarried, and shaped into tombstones, about three miles further south west. On the top of the ridge, the limestone is of a dark color, alternating over a breadth of a mile with bands of slate. In the next ridge, two miles south-east of Waynesburg, the limestone is interstratified with a thinly laminated green slate. Near Waynesburg, the slate becomes more silicious, some of it being reddish, and nearly all of it containing minute scales of mica.

The line of iron ore seems not to extend south-westward much beyond Midduer's; for in crossing its range in several places between Waynesburg and the foot of the mountain, few indications of ore were visible on the surface.

On the southern branch of Antietam creek, near the Maryland line, we again encounter the band of white limestone at Royer's. The bed is several feet thick, but somewhat divided by thin sheets of a greenish slate. It is a beautiful rock, of a white aspect and fine texture, and where large blocks are not required, might be advantageously employed as *marble*.

A rather extensive cavern occurs in the limestone at the north-eastern end of the ridge, a little lower down the same branch of Antietam creek. Lower down the stream, at David Funk's, occurs a grey calcareous and silicious rock, in thin layers, from which excellent flag stones are quarried. Still further down, and near the State line, is a belt of limestone, said to yield a lime which will not slake after being burned.

Near the west branch of Antietam creek, one mile north-west of Waynesburg, is a deposite, of considerable superficial extent, of *travertin* or *calcareous tufa*. A similar deposite is visible near the mill east of Chambersburg, and in several other places along the streams of the limestone region, where the water is highly charged with carbonate of lime. This material, when in a sufficient pulverelerent condition, is an admirable manure, particularly when applied in compost.

The north-west border of the great limestone belt passes through the borough of Chambersburg, in the neighbourhood of which some bands of the rock are *fossiliferous*,—a character which the formation rarely assumes any where in the Kittatinny valley north-eastward of Franklin county.

About seven miles southward of Chambersburg, in a ridge called "Grindstone Hill," we find a bed of sandstone, interstratified with the limestone, yielding a material suitable for rough grindstones.

Advancing from Waynesburg towards Greencastle, we cross alternating belts of limestone and interstratified greenish slates; and beyond these, the limestone, is nearly uniform over a considerable breadth of surface, diversified as usual, however, in color, composi-

tion, and properties. Four miles north-west of Waynesburg, occurs a dark bituminous variety; and in a ridge two miles further, a band nearly white. Immediately north-west of Greencastle, we encounter the line of contact of this wide belt of F. II. and the slates of the base of F. III. This latter rock, to which we shall next proceed, ranges along the north-western margin of the above zone of limestone the whole distance across the State from the Delaware river to this point, and southward into Virginia.

Of the Great Slate Belt F. III. of the Cumberland or Kittatinny Valley.

The uniform character and composition of this wide formation, together with its general deficiency in interesting and useful minerals, will render a detailed description of it unnecessary in the present place. Its south-eastern margin has been indicated in defining the north-western boundary of the limestone. From the Delaware Water Gap to Strasburg, in Franklin county, its north-western limit coincides with the base or flank of the Kittatinny or North mountain, where it supports the massive sandstones of F. IV. occupying the summit of the ridge. From Strasburg to the Maryland line, the slate recedes from the mountain, and is bounded on the west by a wedge-shaped tongue of limestone, the limit between the two rocks passing the villages of Strasburg and St. Thomas or Campbellstown, and intersecting the Maryland line about a mile west of Conecocheague creek.

About a mile and a quarter from the base of the mountain, at the Susquehanna river, the slate includes a thin belt of limestone, imperfectly visible at the river's side. Either the same or another bed is seen about a fourth of a mile nearer the mountain. This belt seems to extend westward several miles,—growing, however, gradually thinner and more slaty, and ceasing, probably, south-east of Sterret's Gap.

In no part of the slate formation have we found the strata possessing the structure and cleavage requisite to produce *roofing slate*. The nearest approximation to that useful variety which we have yet seen, occurs in the bed of the Conedogwinet, above Alter's mill, where the rock is traversed by cleavage plains of tolerable regularity, but is destroyed from usefulness by containing *sulphuret of iron*.

At "Dublin Gap," north of Newville, their occurs a spring highly charged with sulphuretted hydrogen; an analysis of which, together with that of other mineral waters, will be given in a future publication.

Some bands of the slate, particularly those lying adjacent to the limestone, are highly carbonaceous and of a dark color, resembling somewhat the slates of the coal measures. This analogy in their appearance, notwithstanding the conclusiveness of all geological evidence to the contrary, induces many persons, not familiar with our stratification, to suppose that the formation may actually embrace

coal. Excavations have from time to time been made, therefore, at various places in the valley for the last fifty years, in the confident belief that coal would be discovered, and though in every instance unsuccessful, we find them still occasionally renewed.

Of the Belts of Slate and Limestone in the South-Western part of Franklin County.

The south-western portion of Franklin county contains three moderately broad belts of limestone, alternating with three belts of slate, occupying the interval from the margin of the great slate formation above described to the eastern slope of the Cove mountain. An anticlinal axis ranges nearly centrally along each zone of limestone, imparting to the intervening belts of overlying slate a regular synclinal structure. The most eastern, and by far the largest, range of limestone, is that already alluded to as terminating in a long tongue near Strasburg. It is broadest at the Maryland line, and does not materially diminish in width until we trace it about three miles north of the Greencastle and Mercersburg road, where it is about three miles wide. West of St. Thomas, it is but little more than a mile from its eastern to its western border, which is within three-fourths of a mile of Parnell's knob. Here it curves a little eastward, taking a direction about N. N. E. to Strasburg, following the foot of the mountain until it disappears in a narrow point under the overlying slate. The anticlinal axis which runs somewhat centrally along this belt, prolonged beyond Roxbury, seems to extend for many miles towards the north-east, being probably the same axis which separates the North mountain, at Dublin Gap, from the spur lying south of it, and which is thence prolonged through Perry county.

The usual aspect of this limestone is rather uniform. The beds belong to the upper half of F. II.; some of those in the southern part of the tract, near the anticlinal axis, being magnesian, and well adapted, therefore, for furnishing *hydraulic cement.* About five miles north-east of Mercersburg, and two and a half miles from St. Thomas, not far from the anticlinal axis, lies a deposite of iron ore, no longer wrought. It is stated to have yielded a good, soft iron; it was, however short or brittle at a welding heat. When roasted or smelted, it gave off a strong odour of *garlic,*—a circumstance indicative of its containing arsenic. The presence of arsenic in this ore I have ascertained by analysis, the results of which, showing its chemical composition may be seen in chapter VI.

The belt of slate which bounds this tract of limestone on the west, embracing both sides of Claylick mountain, at the Maryland line, ranges a little east of north to the foot of Parnell's knob, where it again separates by receiving the mountain in its synclinal axis, one portion passing along the eastern and the other along the western base and slope. The overlying sandstone beds of F. IV., occupying the tops of Claylick and Parnell's mountains, in the middle of the trough of slate have a nearly perpendicular dip, implying that they

have actually been folded together, along the sinclinal axis, by an action like that of closing a book with its back or cover downwards. West of this belt of slate, the average width of which somewhat exceeds a mile, there ranges a narrower zone of limestone, belonging to F. II., traversed longitudinally by an anticlinal axis, which has lifted the limestone to the surface, and given to the rocks east and west of it the steep inclinations which they possess. This anticlinal belt of limestone, passing out of Blair's valley, between the Claylick and Two Top mountains, at the Maryland line, ranges to the mouth of Bear valley, separating Parnell's from Jordon's knob. Its average breadth is about half a mile. The rock exhibits the usual variety in its several beds, some of which are siliceous, while others again are adapted to produce an excellent pure lime by burning. Certain bands of it are evidently of the kind suitable for hydraulic cement. About a mile and three-quarters from Parnell's knob, the soil above this limestone contains a deposite of iron ore, smelted in the small furnace at Louden,—which was not, however, in operation during the past summer.

West of the last described belt of limestone, ranges another parallel zone of the slate, also about half a mile in width, which, like the former mentioned tract of slate, contains a synclinal trough, in the middle of which lies the Two Top mountain on the south and Jordan's knob on the north.

To the west of this slate ranges another anticlinal belt of limestone, emerging from between the Two Top and Little Cove mountains south of the Maryland line, and ranging along the foot of the latter to Louden, and thence for several miles along the middle of Path valley, vanishing in a narrow point north-west of Fannetsburg. The elevation of this belt of limestone has caused the eastern inclination of the rocks in the Two Top and Jordan's mountains, and the western dips in the Little Cove and Tuscarora ridges. We thus perceive that all the vallies subordinate to these axes of elevation contain the limestone or its next superior rock, the slate, having in every case anticlinal dips; while the mountain ridges included between these vallies, consisting of the higher stratum F. IV., rest invariably in the synclinal troughs embraced between the lines of elevation.

On the west side of the last described tract of limestone, about four miles west of Louden, a deposite of iron ore occurs, formerly smelted in the old Mount Pleasant furnace near it, but now taken to Carrick furnace, four miles towards the north. The ore ranges, in greater or less abundance, for six or eight miles, in a narrow line along the south east base of the Tuscarora mountain, being procured in considerable quantity north of Carrick Furnace. Its position is near the contact of the limestone and overlying slate. It is of two varieties; one a hard ore, occasionally iridescent, making a rather cold-short iron; the other a "honey-comb ore," esteemed of much better quality. The analyses, showing their chemical nature, may be found in chapter VI.

The limestone employed as the flux in Carrick furnace, is procured

in part from a quarry adjacent to the works, and in part from the loose pieces scattered through the neighbouring fields. A little *pipe ore* has been occasionally found.

The narrow belt of slate which overlies the last mentioned range of limestone, occupies the base of Little Cove and Tuscarora mountains, rising nearly to their summits where it supports the sandstone rocks of F. IV. Passing west of Louden and Fannetsburg by Concord, it extends into North Horse valley, between the Tuscarora and Conecocheague mountains in Perry county.

The valley called the Little Cove, bounded by the Cove or Tuscarora mountain on the west, and the Little Cove mountain on the east, presents the strata in a synclinal or basin-like position, the two enclosing mountains consisting of the sandstone F. IV. Both margins of this valley are occupied by the red slates of F. V. seen near the foot of the bounding ridge. The limestone F. VI. encircles the Cove, inside of the red shale supporting in its turn F. VII. is two belts, the north-western ore forming a considerable ridge. The centre of the basin is occupied by the slates of F. VIII. the strata on the west side of the synclinal axis, dipping gently east, while those on the east side are nearly perpendicular. Among the bottom layers of this slate, occurs a highly important bed of iron ore used at Warren furnace. It is a grey *proto-carbonate of iron*, precisely identical in chemical composition with the nodular and plate ores of the shales of the coal measures. The discovery of the true nature of this ore and of the exact place which it occupies in the strata, I regard as among the most useful of the developements of a practical kind made by us during the past year. I shall have occasion in describing the rocks of Huntingdon and Bedford counties, to allude again to this important deposite. Among the analysis in chapter VI. will be found that of this ore as it occurs in Little Cove.

Section II.

Of the Rocks of the Lewistown and Aughwick Vallies and their prolongations, embracing the belt of country extending from the Susquehanna river, to the Maryland line, and bounded on the south-east by the Shade, Black Log and Cove mountains, and on the north-west by Jack's mountain and Sideling Hill.

Lewistown Valley.—Adhering as far as practicable to the order of description adopted for all our formations, I shall proceed to the next most south-eastern belt explored, and trace it from the north-east towards the south-west. For convenience sake I have ventured to give the name of Lewistown Valley, to the belt of country embraced between Jack's mountain and Longstown ridge on the north-west, and Shade mountain and its prolongation, the Blue Ridge, on the south-east, extending the title to the whole of this well marked valley, from the Susquehanna to the Juniata, at Jack's narrows.

A series of narrow, nearly parallel ridges of inferior height to the

bounding mountains divides the general valley into several lesser ones, known by distinct appellations. Thus, a transverse line through Adamsburg, from Shade mountain to Jack's mountain, crosses three separate small vallies. That on the south-east, being the fertile limestone valley of Adamsburg, Beavertown, and Middleburg, that in the middle being the valley of Black Oak ridge, and that on the north-west, the fertile valley known as Moser's valley. These are all traceable to the Susquehanna. The Blue Hill at Northumberland, is a continuation of the Black Oak ridge, while Dry valley containing the town of New Berlin, is but a prolongation of Moser's valley. Along the Bellefonte and Lewistown turnpike, we observe first, the valley, in which Lewistown is situated, beyond this to the north-west another called Dry valley, which terminates a few miles north-east of the turnpike and beyond this again between the limestone ridge at Rawle's forge, and the foot of Jack's mountain, a third, known as Little valley, prolonged to the south-west of the turnpike under the name of Ferguson's valley and Long Hollow.

Formations. The mountain ridges which bound the belt on the south-east and north-west, are composed of the fourth formation of one lower secondary series, divided in my former annual reports into three distinct members. In Shade and Jack's mountains, the lower division of F. IV. is a hard compact sandstone of a greenish hue with some beds of a whiter variety, containing in its superior portion, layers of a reddish coarse conglomerate. The middle division is a red argillaceous sandstone, speckled with yellow *hydrated peroxide of iron.* The upper division is a compact sandstone of several shades of color, white prevailing, jointed into large massive, angular blocks. This last part of the formation usually forms the highest ridge of the mountain, the lower division occupying a bench on the flank of the mountain, often one-third of its height from the summit. In Jack's mountain, these lower rocks form the bench along the south-east side of Kishicoquillas valley, but in Shade mountain only the upper member of F. IV. can be observed, the anticlinal dip of the strata placing it upon the flanks of the ridge, which for most of its length consist of three parallel summits, the central one being constituted of the lower sandstone member of the formation. The whole thickness of F. IV. as it occurs in these mountains is probably about fifteen hundred feet.

The hard grey sandstone of F. IV. graduate by a series of alternations with layers of compact red sandstone into the red and variegated shales of F. V. This last important stratum, together with the limestone F. VI. which it supports, constitutes the most fertile and valuable tracts of the general belt before us. Besides, containing bands of compact and good limestone; F. V. includes in its upper division, which is several hundred feet thick, a soft calcareous shale which readily disintegrates and forms one of the richest soils of the State. The alternating red and grey sandstones at the base of the formation, are sometimes argillaceous, when they can be split and shaped into excellent flag-stones. Some of these abundantly covered

with the fossil remains of the marine vegetation, called *fucoides* have been much employed for the side walks of the streets of Lewistown.

The next division of F. V. is highly argillaceous. The hills composed of it constituting a peculiar feature in the topography not only of this valley, but of the whole district to be described. The lower layers consist of a thin argillaceous brown sandstone, full of the remains of *trilobites*. These support a thick mass of olive and buff colored shales, highly fossiliferous, and upon these reposes a sandstone of variable thickness, but of well marked characters, demanding particular notice, as furnishing our best guide to the exact position of the *fossiliferous iron ore*, which confers so much interest upon F. V. in an economical light. This sandstone and the ore invariably occur in close proximity to each other. The prevailing aspect of the stratum is that of a rather coarse grained, dirty white and yellowish sandstone, containing fragments of *Encrini* and other fossils. It frequently constitutes a small ridge of itself. It may be studied in a fine exposure south of Simon Gros' house, near Shade mountain. It is exposed in many other places, as at the north base of the chain of slate hills, south of Adamsburg and the slate hills, one and a half miles south of Middleburg, where large detached fragments of it abound. These present upon their surface, numerous impressions of *terebratula* and other fossil shells. The *fossiliferous ore* usually rests almost immediately over this bed of sandstone. Above the ore reposes a series of olive and green shales supporting the limestone layers of the formation. Between the Susquehanna and the Lewistown turnpike, these bands of limestone are generally argillaceous or siliceous, and therefore rarely furnish pure lime.

Above the limestone occurs the main bed of red shale and sandstone of the formation, in some places including very hard bands of green and reddish sandstones, breaking into cuboidal fragments. Ascending, the red shale becomes calcareous and alternates with a soft greenish variety which is decidedly calcareous, containing indeed towards its upper portion some thin bands of limestone. This part of the formation is about five hundred feet thick in the vicinity of Lewistown, and furnishes much of the richest soil of the valley. The total thickness of the entire formation is apparently between three and four thousand feet. It occurs along the base of the mountains, forming the hills immediately adjacent to them. It likewise constitutes a belt in Little valley, Dry valley, Moser's valley and the valley of Middle creek.

Overlying the shales of F. V. is the valuable limestone F. VI. of our series. This is the rock of all the limestone ridges throughout the valley. The lower beds are too argillaceous and slaty, to produce good lime, but those higher in the formation supply it of great purity. Near the top of the stratum are bands of very siliceous limestone, abounding in fossils and layers of compact *chert*. This upper division of the rock is frequently too siliceous to be converted into lime. The bed of *chert* is of variable thickness, being sometimes twenty

feet in depth while sometimes it is wholly missing. Its position is generally on the tops and sides of the limestone ridges, its angular fragments covering the surface. On the road from Adamsburg to Shroyer's, it is thirty feet thick.

Immediately resting upon the chert or removed from it but a short distance, are the loose and porous layers of yellow sandstone at the bottom of F. VII. The whole stratum appears to thin out towards the Susquehanna, for here we find only a trace of it, while on the Lewistown turnpike at the toll gate it is seventy feet thick, presenting itself on the surface as usual in massive blocks full of the cavities left by the dissolution of its fossils. The bed itself is not distinctly traceable more than twelve miles north-eastward from Lewistown, but fragments of the rock are seen adjacent to the limestone, at intervals the whole way to the Susquehanna, implying however, that it either is not continuous or is very thin. This sandstone caps nearly all the limestone ridges of the valley from north-east of Lewistown, to Huntingdon county.

Supported by the sandstone beds of F. VII. is a thick mass of slaty rocks, which constitute F. VIII., forming some of the ridges of the central part of the valley; for example, filling a large part of Black Oak Ridge valley to the Susquehanna. The lower part of F. VIII., near its contact with F. VII., sometimes contains a coarse, siliceous and fossiliferous bed of limestone. This is visible on the road crossing the Toll-gate ridge from Lewistown into Dry valley. Above this siliceous limestone, on the flanks of the slate ridges, layers of a purer variety of limestone are occasionally discerned, as at Mr. John Miller's, on Jack's creek. The thickness of this last mentioned belt of limestone is sometimes thirty feet.

In the lower portion of F. VIII. we often meet with a thick series of highly calcareous layers, which sometimes contain bands adapted for making *hydraulic cement*. These beds, which for convenience I have denominated the *cement layers*, are not invariably present in the formation. They are well exposed on the eastern shore of the Susquehanna river, directly opposite Selinsgrove; but between the river and Lewistown, they are scarcely discernible. The limestone previously mentioned is likewise somewhat inconstant. The title of *olive slate* given to F. VIII. in my earlier reports, is entirely applicable to the formation in the belt of country before us. Besides the greenish grey and olive colored slates which make up a large portion of the rock, occur beds of grey sandstone, and occasionally of a massive and compact blue sandstone, slightly calcareous in its composition. These are seen on the road from Lewistown to Sigler's, on Jack's creek. The strata forming the alternations of the materials of F. VIII. and F. IX. are observed as far to the south-west as a line drawn from Middleburg to Centreville. The red and grey argillaceous sandstones of F. IX., so finely exposed on the Blue Hill opposite Northumberland, extend about ten miles south-west of the river, gradually contracting to a point.

From Lewistown, south-ward, the same general valley extends for nearly forty miles, bounded on the north west by Jack's mountain, and on the south-east by Blue ridge, and beyond the termination of that, by Black Log mountain. Its average width is between four and five miles. Approaching Huntingdon county, the whole belt curves southward, conforming to the direction of Jack's mountain. Between Lewistown and the termination of Blue ridge, the general structure of the valley is that of a synclinal basin, including the strata from the bottom of F. V. to the middle of F. VIII., thrown into a number of exceedingly regular parallel lesser anticlinal and synclinal axes, the exact tracing of which becomes a matter of considerable importance from the intimate relation which subsists between them and the distribution of the iron ores of the belt.

Blue ridge terminating at Bell's furnace, its axis of elevation is prolonged seven miles further south-west, being successively overlaid by higher and higher strata, until it flattens away in F. VIII. at Orbisonia. Here the narrow synclinal axis, lying south of it, extending from Negro valley, merges into the general synclinal axis south-east of Jack's mountain; there forming one general trough between Black Log and Jack's mountains, containing the north-west and south-east dipping rocks from F. V. to F. IX. inclusive.

Commencing our description of the several formations of the belt with a brief sketch of the topography of the district, the most conspicuous ridges which we observe occupying the north-eastern end of the valley, at the Susquehanna, are the Blue Hill and the slate ridges adjacent to it on the north and south. These present a range of bold cliffs along the western side of the river. They form a belt extending from two miles above Northumberland to within a mile of Selinsgrove. These hills occupy the central portions of the valley from the river to within eight or nine miles of the Lewistown turnpike. Their outlines are highly characteristic of the formations VIII. and IX. which compose them. Their summits are usually gently rounded, their whole contour undulating, and their flanks intersected by innumerable little transverse vallies of denudation, the slopes on each side of which are of remarkably regular curvature.

The northern limit of these grey and red slaty rocks is immediately south of the limestone ridge which extends through Dry valley and Moser's valley, just south of the towns of New Berlin and Centreville, and on to David Muthbaugh's, where they terminate, a small belt of F. VIII. only continuing to the north of Dry valley. The southern limit, leaving the river about a mile north of Selinsgrove, ranges to Middleburg, bordering on the north the limestone ridge which extends past Middleburg, Beavertown, and John Sigler's. From Middleburg it continues, bordering a narrow belt between the limestone ridge and Dry valley, to the Lewistown turnpike at the toll gate.

On both sides of the hills of F. VIII. we observe the limestone ridges generally covered with fragments of the chert at the top of F. VI. and as we advance towards Lewistown, they become capped

with beds of the fossiliferous sandstone or F. VII. These limestone hills have the form of continuous ridges for many miles. These are occasionally interrupted by gaps, and oftentimes entirely washed away, by denudation, for one or two miles. In Dry valley, in which New Berlin is situated, F. VI. occurs, though not in a bold and continuous ridge. Tracing this limestone, however, towards Centreville, we may often notice it assuming the magnitude of a moderately elevated narrow hill, and preserving this feature through Moser's valley. About nine miles from Centreville, a second and bolder ridge of this formation shows itself, continuing south of Mr. William Smith's, and thence near the base of Shade mountain, until it is interferred with by the axis of elevation of Little valley and Dry valley. Another ridge of the same limestone, ranging south of the slate hills of F. VIII. commences at the Susquehanna, a mile north of Selinsgrove, though other belts occur nearer the town, and runs through the valley of Middle creek, passing north of Middleburg and Beavertown, where another hill rises near it, and then passes Adamsburg, to sweep in a regular curve towards Shade mountain. Here it passes the farms of Mr. John Sigler and others, westward. From Adamsburg, westward, it is the most southern limestone ridge of the whole valley. Its outline is very regular; and its surface, cultivated nearly to the summit, presents a beautiful scollop, constituting a conspicuous and pleasing feature in the scenery. In addition to this ridge, two very singularly shaped knobs of the limestone rises between Middleburg and Beavertown, visible from nearly every part of the valley. In each of them, the rocks have a trough like or synclinal arrangement. The summit of the southern knob is the broadest, and is under cultivation. These knobs owe their elevation to short axes or wrinkles in the strata.

Approaching Lewistown, the ridges composed of the limestone and overlying sandstone become more numerous, dividing the district into several lesser fertile vallies to be alluded to hereafter.

The hills consisting of that division of F. V. comprising the blue grey and olive coloured slates have a somewhat peculiar topography. Their outline is irregular and even ragged. They fold round the ends of Jack's mountain and Shade mountain encircling them at the base. They embrace then usually three summits, the central or broadest, containing the prolongation of the axis of the mountain. Two of these slate hills range along the northern base of Shade mountain, with rather vaguely defined summits from nearly opposite Middleburg, to about two miles east of Beavertown, becoming conspicuously marked from thence to a point three miles west from Adamsburg, leaving the mountain in consequence of a great curve which it takes while they maintain their nearly straight direction. From the above point, to Lewistown, they are less prominently defined in the scenery owing to their close proximity to the mountain. From some cause, no corresponding ridges range parallel with the southern base of Jack's mountain. Enumerating as concisely as possible the several axes of elevation which traverse the belt from the Susquehanna southwest-

ward; the first is the anticlinal axis of Longstown ridge which brings to the surface near its summit the red and grey alternating beds of Fs. IV. and V. This axis prolonged enters Jack's mountain. South of this, the next axis observable on the Susquehanna is the great synclinal depression of the strata controlling the structure of the whole valley. It commences at the river in the Blue Hill, forming a basin in the red rocks of F. IX. and extends southwestward centrally until the uppermost rocks are the slates of F. VIII. It passes about two and a half miles north of Middleburg. Parallel with this is the anticlinal axis observed about a mile north of Selinsgrove, which has lifted the limestone F. VI. to the surface. This is probably but the prolongation of the main axis of Shade mountain marking the line along which the rocks of that ridge have undergone their greatest elevation.

Moser's valley consists chiefly of F. V. and includes two limestone ridges of F. VI. The northern of these seems to be the continuation of that which runs south of Centreville, prolonged with occasional interruptions to within a mile of Mr. John Troxell's, while the southern more elevated ridge ranges far beyond Shroyer's. An anticlinal axis has evidently lifted to the surface the underlaying stratum F. V. occupying the narrow belt between them. There is an anticlinal axis in Middle creek valley ranging near Middleburg, lifting to the surface the red shale of F. V. about a mile and a half from the town, but not bringing up the next lower division of the formation containing the *fossilferous iron ore*. West of south, a little distance, from the town it brings to view the green calcareous shales of the formation. It is thence prolonged between the northern insulated knoll of limestone and the ridge immediately north of Middleburg, disappearing between Beavertown and Adamsburg. A short anticlinal axis elevates the rocks between the pair of limestone knolls and the southern solitary knoll. The effect of the dying out of these axes is to bring the limestone ridge north of Adamsburg, nearer to the foot of the Shade mountain where it finally vanishes.

A new group of axes of elevation present themselves when we approach within ten or twelve miles of the Lewistown turnpike. The first of these ranging about half a mile from the foot of Jack's mountain brings to the surface the red shales of F. V., the second, the calcareous shales along the centre of Dry valley, lifting into view some useful belts of limestone. The third extends along a small valley north of what we have called the "Toll-gate ridge," and the fourth ranges immediately past Lewistown. The most northwestern of these, crossing the Kishicoquillas creek, above the forge of Messrs. Hall and Rawle, is prolonged for about eighteen miles, ranging through Ferguson's valley and terminating in the north-east end of Long hollow. The next towards the south-east crosses the creek about three-fourths of a mile south-east of the former and traversing the ridges which bound Ferguson's valley, passes a fourth of a mile north of Hope, and half a mile north of the Waynesburg furnace, to terminate also near the head of Long hollow. South-east of this, another axis lift-

ing the strata, originates about two miles north-east of Hope furnace, and extends south-west for nine miles passing immediately by this and Waynesburg furnace, to disappear two miles south-west of the latter in the head of Greenbriar valley. The next in order, the third upon the turnpike, crosses Kishicoquillas creek three-fourths of a mile south east of the second, and passing a mile and a half north-west of Lewistown. Its course thence is about twenty miles, ranging three hundred yards south-east of Waynesburg, and ending two miles north of Newton Hamilton at Glasgow's mill. The fifth axis of the group, passing half a mile south-east of Lewistown, ranges south of Strode's mill, forming a ridge running thence nearly a mile south of Waynesburg and through the town of Newton Hamilton, beyond which it terminates. The sixth and last of these lines of elevation, is a continuation of the anticlinal axis of Shade mountain. From the point where this ridge subsides south-east of Lewistown, the axis which has upheaved the strata along its summit, is still prolonged, elevating other rocks for twenty-eight miles to the south-west. It passes two miles south-west of Waynesburg and a mile and a half south of Newton Hamilton, crossing the great loop of the Juniata, and ranging close south of the outlet of Aughwick creek, ending finally at Shirleysburg. Between the fifth and sixth lines of elevation, another axis originates opposite Newton Hamilton which becomes that of Prater's ridge, upilfting there the sandstones of F. VII. The inclination of the several belts of rocks uptilted along these lines of elevation is usually steep and as a consequence, the general valley consists of a number of parallel belts of formations V. VI, VII. and VIII., the softer or more readily denuded of these occupying the vallies, the harder and more resisting composing the intervening ridges.

Iron ores. Having now given a brief sketch, as minute as was compatible with the present report, of the range of the several formations in this belt, I shall proceed concisely to describe the indications of iron ore which they exhibit. The *fossiliferous iron ore* of F. V. is by far the most continuous variety, though after careful investigation we have no where discovered it either pure enough or in sufficient abundance to make it an object of economical interest. It exhibits only occasionally the square fracture characteristic of its purer bands near the outcrop. This feature it has near N. Middleswarth's mill race near Beavertown, but generally it breaks into roundish pieces and consists of much sand cemented by yellowish brown oxide of iron.

A thin seam of this ore extends along the north side of the valley following the flank of Jack's mountain beneath the red shale. It must necessarily cross Kishicoquillas creek, but the thinness of the band has prevented our finding it there, though the hard encrinitic white sandstone so usually associated with it appears well exposed and was extensively traced. The ore seam was not found in place until F. V. was followed into Moser's valley, where the outcrop was detected in a field belonging to Mr. Andrew Romick. The position of the ore in this valley appears to be immediately above the narrow

belt of hard sandstone. Being of the composition above described its quality is bad. Its thickness, probably unimportant, was not ascertained. The same sandstone ridge ranges past the farm of Mr. John Featherolf, accompanied by the ore of too impure a quality, however, to be valuable. Its course eastward ought to be along the base of Longstown ridge, but our efforts to trace it were unavailing, while from observations made during both the past season, and the previous one, in Union county we are led to conclude that it is invariably too thin and impure to be productive. The ore again rises to the surface occupying its usual place in the formation along the south side of the valley adjacent to the base of Shade mountain. We detect it in its true position in a beautiful section of the strata at Mr. Ner Middleswarth's mill. The excavation in the mill race shows the encrinitic sandstone supporting the fossiliferous ore in the form of a very hard and siliceous sand from four to six inches thick. Above the ore rests a mass of greenish shale about one hundred feet thick and over this a somewhat variable shale of a cherry red colour sustaining in turn a series of calcareous shales occupying the place of the limestone bands of the formation and supporting the well known brownish red shales at the top of the series. No difficulty existed in tracing the ore along the base of the slate hills south of Adamsburg and Beavertown, and it was also followed along the foot of the slate hills south of Middleburg, but it is rarely of sufficient purity, and in no place thick enough to make it practically useful. Near Lewistown, especially seven miles to the west, it has been opened in many places, and its thickness though increasing in that direction is even there not considerable.

Another distinct band of ore occurs sometimes in F. V. among the buff and olive shales already described. It is of a light brownish colour, and is generally too small in amount and too impure, to be valuable.

The limestone ridges of F. VI. frequently exhibit considerable quantities of iron ore upon the surface; yet, from the shallow depth of the earth above the rock, and from other indications, we deem the prospect a slender one of finding a useful deposite in this formation as it occurs in Union and Mifflin counties. This superficial display of ore is visible on the ridge north of Adamsburg, and also on one of the isolated knobs near Beavertown.

No useful quantity of ore would seem to occur in either F. VII. or F. VIII. north-east of the Lewistown turnpike. The first of these formations dwindles in thickness as it approaches the Susquehanna, and also is much less ferruginous than in Huntingdon and Bedford counties.

F. V. South-east of Lewistown.

Lewistown is situated on the border of F. V. and F. VI. or of the shales and limestone, F. V. occupying the entire space from the town to the base of the mountain south-east of it, called Blue Ridge.

This belt is at least one mile and a half wide, and continues of this breadth as far as Waynesburg. At Lewistown, the stratum have been lifted to the surface by two anticlinal axes, while opposite Waynesburg it is thrown up in three lines of elevation. The first of these, south of Lewistown, begins to form a ridge east of Strode's mill, which continues for six miles, ending south of Waynesburg. This ridge is composed of the fossiliferous sandstone belt of F. V. and has the fossiliferous iron ore resting on both of its flanks. South-east of Waynesburg, the limestone F. VI. lies in the synclinal axis. South of the anticlinal axis, and three miles south-west of the same town, F. V. with the fifth anticlinal axis in it, is overlaid by the limestone.

The anticlinal axis of Shade mountain, in elevating F. V. brings the fossiliferous iron ore to the surface, in a double line of outcrop, for a mile and a half south-west of the end of the mountain, beyond which the ore sinks below the surface—the axis exposes the higher parts of F. V. for about fifteen miles, when the red shales disappearing altogether, it is prolonged in the limestone beds of F. VI., entering this formation opposite Galloway's Gap, in Blue Ridge. The limestone forms a trough between this axis and the mountain, commencing between four and five miles east of this point and extending to the bend of the Juniata, a narrow ridge of the overlying sandstone of F. VII. rising near Galloway's Gap, and running along the centre of the basin to the river.

The belt which ranges along the base of Blue Ridge being separated from the other belt elevated by the Shade mountain axis by this tract of limestone, ranges towards the south-west, passing Bell's mill, and finally folds round the end of Blue Ridge, to enter the synclinal basin of Negro valley. The rocks of this formation, resting at the foot of the mountain, extend about one-third of the way up its aclivity, and spread into the valley a few hundred yards from its base, dipping to the north-west, at an angle of about fifty degrees. Where it saddles the axis of Blue Ridge, it lengthens itself to the south-west so as to form a considerable portion of Germany valley, the hard sandstone stratum forming a curious semicircular ridge sweeping round the end of the mountain. In Negro valley, this formation lies in a trough, or, in other words, its strata dip from both sides towards a central line or synclinal axis, being elevated on the north-west by the anticlinal axis of Blue Ridge, and on the south-east by that which has uplifted the Black Log mountain. Nearly opposite the end of Blue Ridge, the upper strata of F. V. are overlaid in the middle of the basin by the next succeeding formation, the limestone. The north-west dipping beds of F. V., resting at the base of Black Log Mountain, form a belt which ranges with great regularity along its flank for eighteen miles, to Fort Littleton. The mountain then terminating, the zone of red shale is joined by another which follows the south-east flank of Shade mountain, and the two fold together at Littleton over the anticlinal axis prolonged from Black Log valley, forming a tract of good soil, occupied by several farms.

FORMATION V.—*North-west of Lewistown.*

The formation at Brown's gap, where Kishicoquillas creek passes through a deep notch in Jack's mountain, is about a mile and three-quarter's wide, forming the north-west side of Ferguson's valley, and extending half way up the slope of the mountain. This belt of F. V. is traversed by the first anticlinal axis of our enumeration, which lifts to the surface the *fossiliferous* ore about two miles south-west of the gap. The existence of the ore is indicated by a ridge extending along the north-west side of Ferguson's valley, and which consists of the grey sandstone stratum of F. V., immediately supporting the ore. The anticlinal axis running along the centre of this little ridge of sandstone, the fossiliferous ore is brought up in a double line of outcrop, one portion resting on each flank. The ridge extends south-west between five and six miles, where the gentle subsidence of the strata over the axis causes the ore to disappear below the surface; and two miles further south-west, the whole of F. V. itself, along the line of the axis, also passes out of view, being overlaid by the limestone. For some distance previous to the disappearance of the red shales along this axis, the limestone occupies a narrow trough between this range of the formation and the other which rests against the foot of the mountain. This latter belt of F. V. its beds dipping about thirty degrees towards the south-east, continues along the slope and base of Jack's mountain for about nine miles, when it begins to recede from its flank so as to rest only at the mountain's base when we reach Drake's ferry. This portion of it, therefore, forms the north west part of the valley called Long Hollow, the strata here dipping twenty-two degrees to the south-east.

Traced south-westward from the Juniata, F. V. occupies the north-west side of Dry valley—a valley lying between Jack's mountain and Chesnut ridge. Here its beds dip thirty-five degrees to the south-east. It preserves this position at the base of the mountain, which it follows to its termination, about fifteen miles, folding round its south-western end, at the Three Springs, to meet a parallel belt occupy the other base of the mountain in Hare's valley. Where the formation climbs some distance up the flank of the mountain, the hard grey sandstone forms a slight but distinct ledge along its slope; but where it rests only at the base, this band constitutes a sharp-crested ridge, ranging through the south west end of Long Hollow, and traversing the north-west side of Dry valley for a considerable distance.

Fossiliferous iron ore of F. V.

With a single exception, all the furnaces situated in the belt of country before us from Lewistown to Maryland, being nine in number are supplied with two varieties of iron ore. One of these is the fossiliferous ore for the formation above described. The other belongs to

the lower layers of F. VIII. to be hereafter noticed. Their distribution being entirely dependant on minute features in the geological structure of the valley connected with the axes of elevation, the work of tracing then becomes a matter of systematic research, making a correct knowledge of the position of the strata and their axes, of indispensible importance.

Confining ourselves for the present to the fossiliferous ore of F. V. I deem it useful again to allude to its close association with the grey fossiliferous sandstone which forming often a prominent feature on the surface proves so valuable an index to its position. Generally throughout the belt of country before us, the uppermost layer of this sandstone is a hard bed varying from fifteen to thirty feet in thickness, consisting sometimes of a fine grained white or yellowish brown rock, filled with numerous cavities of *encrini* and other fossils.

The fossiliferous ore besides cropping out in a narrow line following the flank of each of the mountains bounding the general valley, is lifted to the surface for a certain distance along two of the anticlinal axes which traverse the district between Lewistown and the Juniata at Drake's narrows. The belt of ore on the flank of Jack's mountain has not been opened north-east of Drake's Gap. Here however, it has been smelted in Matilda Furnace, making a good iron. At this place the whole thickness of the seam of ore is about sixteen inches, the upper half, only, however, being pure enough for the furnace. This, averaging about eight inches in thickness, is very similar in aspect and composition to the ore of acknowledged excellence in other parts of the same deposite, being hardly distinguishable from that of Montour's Ridge, or that of Woodcock valley at the base of Tussey's mountain. It is rather less rich in iron though in other respects quite as good. This belt of eight inches is separated by a band of three or four inches of tough greenish slate from a lower layer of nearly equal thickness, containing only about half the proportion of iron in the former and consisting largely of sand and other extraneous matters. Though possessing somewhat the aspect of the true fossiliferous ore above it, it is too siliceous and too poor in metal to make it useful, even for mixing with the richer ore. The two analysis given in chapter VI. will show the composition of each of these divisions of the ore bed at Matilda furnace.

The same bed of ore presenting very nearly the same features occurs in Dry valley, south-west of the Juniata. One of the belts thrown up by the anticlinal axis of the north-west side of Ferguson's valley, has been opened at several points for the supply of Hope furnace. It is the southern dipping band, the northward dipping ore being very steep which as a general rule somewhat lessens the value of the stratum.

The ore brought up to the surface by the fifth anticlinal axis of the valley extends from a point south-east of Strode's mill, to a point south-east of Waynesburg, accompanying the usual ridge of sandstone. The bed in this range is not more than four or five inches thick, but resting upon the upper layers of the hard sandstone and overlaid by

a very shallow covering of soft shale it is readily accessible. In some places it nearly saddles the axis of the ridge near the north-east extremity, of which several excavations have been made; the ore is used at Hope furnace.

The band of ore extending along the north-west flank of Blue Ridge has not been opened between Lewistown and Bell's mill. Near the latter place the Juniata cuting the belt of sandstone at the bluff called Blue Rock, exposes the ore which exists here in two thin layers not of sufficient magnitude to be valuable. At Bell's furnace the same layers as they sweep round the termination of Blue Ridge have been worked, though their insufficient thickness has caused them to be abandoned.

F. V. in Pigeon Cove.

Pigeon Cove, commencing in the southern part of Bedford county, and extending into Maryland, is a small valley of elevation consisting of F. V. bounded on all sides by a rim of hills composed at their base of the limestone F. VI. Its length in Pennsylvania from the State line to the head of the valley is between six and seven miles, and its width at the Maryland line is about a mile and a half. The axis of elevation which has upheaved the shales of F. V. along the middle of this valley and caused the adjoining strata to dip away in opposite directions, is apparently a prolongation of the great axis of Black Log valley, which there brings to the surface a much deeper seated set of rocks. Had the uplifting action been only a little more powerful, or the denudation deeper in Pigeon Cove, there can be no doubt that a valuable band of the fossiliferous ore would have been exposed, inasmuch as further to the south in Virginia, where such a state of things prevails the bed reaches the surface in two parallel lines of outcrop. As it is, only the superior portion of the formation lying above the ore is exposed.

F. V. at the base of Scrub Ridge.

The red and variegated shales or F. V. probably exist in a perpendicular attitude at the base of Scrub Ridge, extending from the Burnt Cabins for six or seven miles towards the south-west, where they are lost below the surface in consequence of an enormous dislocation of the strata which extends along the north-west side of the McConnellsburg Cove. They emerge again south-west of Hunter's mill, and thence extend along the flank of Dickey's mountain, to its termination, folding round to meet another belt of the same formation, which occupies the north-west side of the Little Cove.

F. V. in Little Cove.

A wide border of F. V. encircles the valley called Little Cove. Commencing high up on the slopes of the Cove mountain, just where the Chambersburg turnpike ascends it, north of Louden, the formation ranges along the trough or synclinal axis of the valley in a S. S. W. direction between nine and ten miles, where the deepening of the basin permits the red shales to be overlaid along the south-eastern side, by a belt of limestone, F. VI. which divides it into two zones. That on the north-west is broad, its strata having a rather gentle inclination to the south-east, about thirty degrees, the formation spreading over a considerable portion of the north-west side of the cove. Towards the south-west this gradually contracts and finally unites as before mentioned with the belt which sweeps round the end of Dickey's mountain near the State line. The other or south-eastern zone is narrow and extends high up on the flank of the Little Cove mountain, its strata being nearly perpendicular.

Formation V. as it appears in Little Cove, includes two important beds of sandstone, each nearly one hundred feet thick, separated by about the same thickness of olive and yellowish beds of shale. The lower of these is a red sandstone, the upper, a white sandstone, and the position of the *fossiliferous iron ore*, is in the shales which lie between them. These belts of sandstone constitute the ridge along which the turnpike ascends from a mile north of Louden to the toll gate on Cove mountain. Along the north side of Little Cove, they likewise range in a high ridge, upon the east of which the *fossiliferous ore* was traced for eight or nine miles south-west, from the Mercersburg turnpike. On the south-east side of the Cove, these sandstones do not give rise to a separate ridge but rest high up in the slope of the bounding mountain.

The fossiliferous ore thus discovered cropping out along the north-west side of the synclinal axis of Little Cove, was traced by the fragments scattered on the surface for nearly fifteen miles.

Formation VI.—*Fossiliferous Limestone.*

F. VI. from Lewistown to Fort Littleton. Between the first and second anticlinal axes north-west of Lewistown, occurs a synclinal axis in the *fossiliferous limestone* F. VI. which forms a high ridge on the Bellfonte turnpike. The second or northern anticlinal axis, lies also in the limestone. But about a mile towards the south-west the sandstone F. VII. begins to occupy the line of the synclinal axis separating the limestone into two belts. That on the north-west, bordering the south side of Ferguson's valley, and continuing for nine or ten miles, ranges at the base of the sandstone ridges, until nearly opposite Waynesburg, where it folds into the limestone of the basin north of it, saddling the northern anticlinal axis coming out of Fer-

guson's valley. This belt is thence prolonged to the south-west about two miles further where a ridge of sandstone begins to overlie the northern side of it, subdividing it for about four miles, into two narrow tracts and then ceasing in order to allow these to reunite at the north-east end of Long Hollow.

The second anticlinal axis counting southward from the mountain, elevates to the surface a narrow belt of the limestone varying from two to six hundred yards in width, and extending from a point north of Lewistown to Atkinson's mill, a distance of eighteen miles. For a portion of this distance it forms the crest of a ridge flanked on each side by the sandstone beds F. VII. About a quarter of a mile north-west of Waynesburg furnace, this ridge has been cut down by denundation into a little valley about two miles in length. At Atkinson's mill in the east end of Long Hollow the narrow ridge of sandstone lying between this limestone and another belt of the same rock on the north ceasing, the two merge together into a broad tract, nearly a mile in width, having two anticlinal axes near its eastern end which die out two or three miles to the south-west in Long Hollow. The limestone extends along the south-east side of this valley dipping only in one direction, or towards the south-east. Where the belt reaches the Juniata, it is half a mile wide. Traced still further towards the south-west, it forms the south-east side of Dry Valley, and reposes at the base of Chesnut Ridge under the sandstone F. VII. Preserving a gentle dip it advances about fifteen miles beyond the Juniata, to the Three Springs where it folds over the red shales which saddle the axis of Jack's mountain and meets the belt that in a similar manner traverses Hare's valley.

The third anticlinal axis counting from the mountain, which does not appear on the Bellefonte turnpike brings into view a narrow belt of the limestone, commencing about two miles north-east of Hope furnace. In its course towards the south-west it passes under this furnace and also under the Waynesburg furnace, ending a mile and a half south-west of the latter. It is overlaid on each side and at both ends by the sandstone F. VII. constituting the crest of a ridge a few hundred yards in breadth while the sandstone forms the flank.

The fourth anticlinal axis developes the limestone a little north of the toll gate near Lewistown. This rock then constitutes the crest of a ridge flanked on both sides by the sandstone. Its width is between three and four hundred yards. About five miles south-west o Lewistown, it merges into the next adjacent belt of limestone which passes immediately by Lewistown. The synclinal axis or trough between the ranges is occupied by the sandstone capped by the slates of F. VIII, which there cease. The limestone beyond this point consisting of but one narrow belt, ranges north of Strode's mill and south of the sandstone ridges passing the town of Waynesburg, a mile beyond which it again widens and finally divides into two projecting points or tongues by the commencement of a broad ridge of sandstone lying in the synclinal trough between the fourth and fifth anticlinal axis. The north western range runs for a mile and a half and

then disappears beneath the overlying sandstone about four miles south west of Waynesburg. The south-eastern portion ranges about four miles further, following the fifth anticlinal axis along which it joins another belt of the same limestone which commences south of the Juniata about two and a half miles east of Waynesburg. The broad belt formed by the union of these two, is a second time subdivided by a ridge of sandstone, at a point near the canal about five miles below Newton Hamilton, the northern prong running to a point between sandstone ridges about a mile and a half to the west, while the southern division extends in a regular belt to the great bend of the Juniata. This latter range when opposite to Galloway's Gap, is joined by another occupying a narrow trough at the foot of the mountain which commences about three miles south of Waynesburg, and half a mile south-east of the river. This last and most south-eastern belt containing a synclinal axis embraces along its centre a narrow ridge of the overlying sandstone commencing opposite Galloway's Gap and running to the bend of the Juniata, dividing the limestone into two vallies. That next the mountain called Sugar Valley, is the narrowest. The limestone ranging along the north-west side of this ridge and between it and another sandstone belt following the Juniata, gradually contracts in width towards the bend of the river, which it crosses one mile south of Newton Hamilton passing the mouth of Aughwick creek and becoming the crest of Owen's ridge. It ceases altogether about a mile north-east of Shirleysburg, where it is overlaid by the sandstone F. VII.

Prater's ridge, consisting of the limestone and overlying sandstone, owes its elevation to an anticlinal axis, developed in the latter. It commences south-east of Newton Hamilton, and extends for about three miles, running close to the north-west base of Owen's ridge, forming a narrow trough or synclinal valley of F. VIII. between them.

The subdivision of the limestone which traverses Sugar Valley, crosses the bend of the Juniata north-west of Bell's mill, beyond which it borders the north-west side of Germany valley, at the south-east base of Owen's ridge. At the western extremity of Germany valley, three miles from the end of Blue ridge, the zone of limestone closes over the anticlinal axis prolonged from the mountain, and sweeps round towards the east and forms a basin at the mouth of Negro valley. Thus augmented in breadth, in curving round the head of Germany valley, it becomes soon subdivided, by receiving in the middle of the basin, south of the end of that valley, a sandstone ridge of F. VII. separating it into two distinct belts towards the south-west. The most northern of these ranges three miles from the commencement of the ridge, and finally disappears, one mile north-east of Orbisonia, in the anticlinal axis, where it is saddled by the sandstone. The other, or south-east division, ranges towards the south-west, with great regularity, for fourteen miles, following the base of Black Log mountain. It passes north of Winchester furnace and

south-east of Madden's mill; and about a mile south-west of Littleton, it meets the belt which pursues the south-east base of Shade mountain.

F. VI. at the Foot of Scrub Ridge.

At the Burnt Cabins, near the line of Bedford county, the limestone is seen in a perpendicular position, extending along the north-west side of the prolongation of the anticlinal axis of the cove. It probably continues south-west for six or seven miles in that altitude, until lost in the great dislocation, before referred to, at the base of Scrub Ridge. It emerges again on the north-west flank of Lowrey's knob, and passes thence a short distance south-east of Hanover furnace, and along the base of Dickey's mountain, where it passes into Maryland, and finally folds round the end of that ridge, saddling its anticlinal axis, and uniting with the north-western belt of the formation in Little Cove.

F. VI. in Little Cove.

The limestone begins to show itself along the south-east side of the Little cove, south-west of the Mercersburg turnpike, and extends down the cove for several miles, when the overlying sandstone commencing, it divides, one belt crossing the cove westwardly to follow its north-western side, the other belt preserving a steeper dip, running along the south-east side of the base of the Little Cove mountain. The first range passes three-fourths of a mile north-west of Warren furnace, and crosses the State line at the base of a ridge capped by the sandstone.

Pigeon Cove is belted on both sides by this limestone, having its usual fossiliferous character. It forms the base of the enclosing hills, called the Conolloway ridges.

Iron Ore.

This limestone formation has been carefully examined throughout the several belts here described, with a view, if possible, to discover workable deposites of iron ore. In many places, indeed, it exhibits in the soil scattered lumps of a compact chesnut brown ore, of excellent quality; but the shallowness of the earth resting over this rock, and other causes, seem to have prevented the accumulation of large deposites, such as we find in the great belts of limestone belonging to F. II. Somewhat extensive accumulations of ore do occur in the ridges at the base of which this limestone usually lies; but these are subordinate rather to the sandstone F. VII., which caps those ridges, than to the underlying limestone. They will be mentioned, therefore, in the next section.

Formation VII.—*Fossiliferous Sandstone.*

Formation VII. from Lewistown to Maryland. In the belt of country at present before us, this sandstone is of no great thickness, varying from fifty to one hundred feet. Its lower beds consist of an argillaceous buff coloured sandstone, in which the siliceous particles, though abundant, are often of extreme minuteness. Its colour is yellowish or buff, and it breaks into rectangular fragments. Its upper portion, on the contrary is a coarse grained sandstone, usually white or brownish. Wherever this formation appears, it almost invariably constitutes a sandy and rugged ridge. The most north-western ridge of this formation, lying near the foot of Jack's mountain, commences two miles north-west of Waynesburg, and terminates one mile north of Atkinson's mill. The next begins about a mile south-west of the Bellefonte turnpike, and ranges for seventeen miles, including, probably, in its trough, a narrow belt of F. VIII. for most of this distance. It bounds Ferguson's valley on the south-east, passes north-west of Hope furnace, thence by Huling's saw-mill, and ends north of Atkinson's mill, near one of Mr. Patton's ore banks. The third belt commences about a mile north-west of Lewistown, and separates into two ridges, about two miles north east of Hope furnace. That on the north-west, embracing a narrow strip of the slates of F. VIII., passes north-west of the furnace and a few hundred yards north-west of Waynesburg furnace—two miles beyond which it widens out, admitting a wider belt of the slate upon it, which soon divides it into two ridges, the south-eastern ending near the head of Green Briar valley, and the other continuing to the south-west, bordering that valley and Long Hollow to the Juniata. Arriving at the river, this belt crosses and becomes Chesnut ridge, bounding Dry valley on the south-east. It continues thus for fifteen miles to the Three Springs, where it forms a semicircular ridge, sweeping round beyond the end of Jack's mountain to meet another belt, forming Rocky ridge, in Hare's valley.

The south-eastern division of this ridge, with which we started at the turnpike north of Lewistown, passes two hundred yards south-east of Hope furnace and several hundred north of the town of Waynesburg, to the south-west of which it divides, sending one portion to unite with the ridge which ends at the head of Green Briar valley, and the other further to the south-west, to form the general south-eastern boundary of Green Briar valley, and to form a part of the broad table land of sandstone which occupies most of the space between this valley and the Juniata, and which ends near Newton Hamilton.

Another sandstone ridge, the most south-eastern of the series, seen immediately north-west of Lewistown, extends for several miles along the Huntingdon turnpike until it terminates about half a mile north of Strodes' mill. This belt of sandstone, like most others, supports a

narrow strip of F. VIII. along its summit, protected from denudation by occupying the middle of a trough in the strata.

The broad table land of sandstone already mentioned, sends a narrow ridge or tongue, ending a little west of Newton Hamilton. It also, in consequence of a short anticlinal axis, protrudes another similar promontory across the Juniata, at the dam below that town; while the ridge forming its south-eastern margin, crossing the river a third of a mile below the dam, recrosses it twice more at the bend, and passes it just at the mouth of Aughwick creek, and thence runs to Shirleysburg, flanking Owen's ridge on the north-west.

The short anticlinal axis of Prater's ridge brings up the sandstone south of Newton Hamilton. This belt of the formation crosses the bend of the Juniata, and forms, with the belt just described, a narrow trough, extending between two and three miles south-west, and embracing a little belt of the slates of F. VIII., forming a valley for Aughwick creek.

The south-eastermost belt of sandstone is the ridge bounding Sugar Valley. Commencing opposite Galloway's Gap, it soon includes, like the rest, a narrow zone of the the dark slates of F. VIII. lying along the trough in its summit. This zone of F. VIII., becoming thicker towards the south-west, embraces, about three miles from its origin, a highly important band of *iron ore*, opened at Mevey's ore bank. The ridge, and its contained belt of slate, crossing the Juniata north of Bell's mill, presents us with another exposure of the ore at Bell's ore bank. The band of ore follows the slate for some distance towards the south-west, lying now nearly on the crest of Owen's ridge. The belt of slate widening and deepening towards Shirleysburg, the sandstone ridge separates—one part folding over the axis of Owen's ridge to meet the corresponding sandstone beds of its north-western flank, terminates near Shirleysburg; the other running on to the south-west, ends near Orbisonia, by saddling, in like manner, the axis prolonged from Germany valley, and uniting with another belt of sandstone, forming part of Sandy ridge, on the south-east. This last named ridge crosses Black Log creek above Winchester furnace, and continues thence parallel to Black Log mountain, with a uniform north-west dip, for several miles. Near the south-west end of Black Log mountain, it gradually leaves its base—Aughwick creek flowing in the limestone valley between them. The sandstone ridge north-west of Littleton is a continuation of this belt of F. VII., which meets a corresponding belt that ranges along the south-east side of Shade mountain, at a point about a mile and a half south-west of Littleton, where the two fold together, saddling the anticlinal axis of Black Log valley.

The sandstone F. VII. as developed at the base of *Scrub Ridge*, consists only of a few layers of fine conglomerate and some massive beds of calcareous sandstone, containing the common fossils of the formation. It is in all probability not more than twenty feet thick. It loses itself a few miles north of McConnelsburg, near the commencement of the great dislocation at the foot of Scrub Ridge, and does not emerge again towards the south-west for several miles.

When it does appear it follows closely the range of the underlying limestone before described.

In *Little Cove*, the formation consists of beds of fine conglomerate and of coarse sandstone much impregnated with iron. Between five and six miles south-west of the Mercersburg turnpike, and three miles south-east of Warren Iron works, the sandstone commences in the synclinal axis of the Little Cove. It soon separates into two belts, that on the north-west, forming a considerable ridge running near the side of the Cove, and about three fourths of a mile north-west of the Warren works. The other division ranges along the south-east side of the Cove, forming also a distinct ridge, which passes about the same distance south-east of these works.

The ridges bounding *Pigeon Cove*, are capped by this formation developed in considerable thickness. The rock consists of a fine grained conglomerate and a coarse brownish-yellow sandstone, having the usual appearance and the characteristic fossils of F. VII.

Iron Ores of F. VII.

Near Chester Furnace in Huntingdon county, there is a valuable deposit of cellular brown iron ore in the belt of F. VII., which composes Chesnut Ridge. The sandstone here consists of two members, the upper a soft coarse grained sandstone, the lower a buff coloured, fine grained and very argillaceous sandstone, remarkable for its square cleavage. Precisely at the junction of these two strata, occurs the ore in a bed usually about two feet thick. It is generally more or less sandy and what is even more detrimental, contains frequently a large amount of *oxide of manganese*. It seems to be derived from the filtration through the upper porous and ferruginous sandstone carrying down the oxide of iron to the top of the less penetrable argillaceous bed beneath. This ore has been dug at several places, but the efforts hitherto made to smelt it have proved unavailing in consequence of its extreme impurity.

Formation VIII. Dark Olive Slates.

In the belt of country before us, the lower layers of F. VII. consist for the first thirty feet or thereabouts of a very dark slate. Above these occur the calcareous beds called by us the *cement layers*, from containing occasionally a good *hydraulic cement*. These are generally but a few yards thick. Over them, varying a little as to their precise position, are bands of an impure *carbonate of iron*, which when unaffected by the action of the atmosphere is of a bluish-grey or lead color. These support a thick mass of black slate upon which repose in turn the grey sandstone and olive slate, distinctive of the middle divisions of the formation. Higher in the series are buff, olive, and sometimes pinkish slates, generally very soft and friable.

In the greater number of the synclinal ridges of the sandstone, a

narrow trough running centrally along the summit, contains only the black slate at the very base of F. VIII.

In the ridges of a different structure this black slate occupies a narrow valley with the coarse sandstone of F. VII. on one side, and hills of the grey sandstone, and olive slate on the other. The hills of the upper part of the formation are more rounded. These features in the topography are thus specified, as affording an important clue to the range of the iron ore above described, which seems to be a continuous bed, following the calcareous layers of the lower part of the formation, sometimes for a mile. From the general steepness of the dip in the several belts of the sandstone F. VII. and from its trivial thickness, these valuable lower layers of the overlying stratum F. VIII. have been effectually protected from denundation along the troughs or synclinal axes, affording a beautiful provision for the protection and distribution of the iron ore.

In tracing the narrow ridges of the sandstone, I took occasion to mention these included belts of the lower layers of the overlying slate: it is needless therefore to describe again their range. I shall therefore, mention only those belts in which the important ore accompanying them is worked.

The ore bank one mile north of Atkinson's mill, wrought by Mr. Patton, for the supply of Hope furnace, is situated in this formation. The belt here is that of the second sandstone ridge, south of Jack's mountain, lying between the first and second mentioned axes.

The ore dug a little west of Waynesburg furnace, occurs in the belt between the second and third anticlinal axes.

The ore diggings of Chester furnace, belong to the lower layers of F. VIII., cropping out on the north-west side of the wide basin of great Aughwick valley, a continuation of that of Green Briar valley.

Mevey's and Bell's ore banks already mentioned, occur in the synclinal axis between the sixth anticlinal axis and Blue Ridge, in the corresponding belt of F. VIII. on the summit of the sandstone ridge.

Morrison's ore bank is on the outcrop of the same lower layers of the slate on the south-east side of the synclinal axis, between Prater's Ridge and Chesnut Ridge.

The ore banks of F. VIII., near Orbisonia, are in the same synclinal axis, which is continued from the middle of Negro valley.

The precise geological situation of this valuable and most extensive band of ore is here given, in the hope that individuals interested in the subject, may by attending carefully to our descriptions of the formations in their several complicated belts, and by taking as a guide the various anticlinal axes or lines of elevation, and synclinal axes, or lines of depression, trace for themselves the course which it takes along the hills. The discovery in the prosecution of our researches of the continuous nature of this ore in the lower layers of F. VIII., and of the no less valuable bed of fossiliferous ore peculiar to F. V. furnishes just cause of satisfaction to those engaged in the geological survey.

Green Briar Valley.

Formation VIII, with gently dipping strata, commences at the north-east end of this basin, two miles from Waynesburg, where two narrow belts which previously occupy the summit of the third and fourth sandstone ridges, counting from Jack's mountain, coalesce by the dying out of the anticlinal axis of the limestone valley of Waynesburg furnace. This valley is widest opposite Glasgow's mill, on Beaver run, being there about a mile and a half from south-east to north-west.

South-west of Newton Hamilton, where the fifth anticlinal axis with its ridge of sandstone ends, it merges into another broad belt of F. VIII. lying north of Prater's Ridge, the united tracts of the olive slate being here two miles in breadth. Prater's Ridge uplifted by an anticlinal axis separates this broad belt for a space into two, forming a narrow one between it and Owen's Ridge, and leaving the principal portion of the formation on its north-west, spreading across the whole of the great Aughwick valley to the base of Chesnut Ridge. The belt then continues to the south-west, bounded by Chesnut Ridge and Owen's Ridge, the latter ending at Shirleysburg. Here the main basin of F. VIII. is about two miles wide. Beyond the end of Owen's ridge, its boundary on the south-east, is the ridge of sandstone which terminates at Orbisonia. At Shirleysburg, the main belt is joined by a narrow one, the same which contains Mevey's and Bell's ore banks, coming from the Juniata and opening here into the general basin. In like manner another narrow tongue of F. VIII. commencing on the summit of Sandy Ridge, a short distance from its north-east extremity near Germany valley, expands by a division of this ridge and merges itself into the general body of the formation at Orbisonia, beyond which to the south-west, the main basin of F. VIII. containing but one central synclinal axis, is bounded on the south-east, by the sandstone ridge which follows the foot of Black Log mountain, and on the north-west, by that which ranges near the base of Jack's mountain. In this part of its course it is two and a half miles wide, its surface diversified with rounded swelling hills of the slate.

About three miles west of Orbisonia, and a little beyond the junction of Three Spring creek and Aughwick creek, an extensive belt of the thick overlying stratum F. IX., commences in a ridge occupying the synclinal axis in the centre of the basin. This tract of red argillaceous sandstone divides the olive slate formation into two ranges, that on the north-west running on and meeting the slate belt which traverses Hare's valley, these saddling at their junction the anticlinal axis prolonged from Jack's mountain. Where this occurs, the belt is three miles in width, being bounded on the north-west by Cleur ridge. Rapidly contracting, it forms a triangular area terminating in a point eight miles south-west of Jack's mountain, when it is overlaid by the red rocks of F. IX.

The other zone of olive slate lying between the sandstone ridge at the base of Black Log mountain and the margin of the red sandstone on the north-west, runs towards the south-west, between ten and eleven miles, meeting a belt of the same formation sweeping round from the south-east side of Black Log valley, at the base of Shade mountain, at a point two miles south-west from Fort Littleton. Opposite Littleton, the belt forms a basin of simple synclinal structure, lying between the anticlinal axis of Black Log valley, and the M'Connelsburg Cove. On the north-west side the strata have a gentle dip to the south-east, but adjacent to Scrub ridge, they are perpendicular, being affected by the dislocation.

About three miles south-west of Littleton, another tract of F. IX., commences, dividing this part of the olive slates into two ranges, one stretching along the base of Scrub ridge, and the other uniting with the belt north-west of Littleton, by saddling the axis of Black Log mountain three miles from its termination. The wide belt thus composed sweeps westward to occupy the centre of the valley between Sideling Hill and Big Scrub ridge, continuing as one belt two and a half miles in width, for sixteen miles, to the north-east extremity of Pigeon Cove. Here the lower formations being protruded, it separates, one division running north-west of the Cove, the other south-east, until they both reach the Potomac.

The *Scrub Ridge* belt is *overtilted* or *inverted*, the strata dipping eighty degrees to the south-east. A considerable portion of the formation is buried under the dislocation. Opposite to M'Connelsburg, it is four hundred yards in breadth. Further west where Scrub ridge itself ceases, the hills of this formation bound the Cove. It emerges to the surface again near Hunter's mill, and at Hanover furnace, the entire formation is once more developed though its beds are still perpendicular. In this attitude it crosses into Maryland.

Little Cove, contains in the middle of its basin a broad belt of F. VIII., having a width of a mile and a half where it is intersected by the State line. Gradually contracting towards the north-east, it terminates in a point a little more than three miles north-east of Warren Iron works. The strata on the north-west side of the synclinal axis dip gently towards the south-east, while those on the south-east side are perpendicular. Warren Iron works are situated near the centre of the belt.

Iron Ore in F. VIII.

The discovery of the true nature and exact position of the iron ore connected with this formation, furnishes an interesting illustration of the utility of geological researches systematically prosecuted. The ore having been previously dug at the out crop, only at remote and scattered points, no general clue to its position applicable in practice had been detected, nor was it probable that any could be, until the order of superposition had been minutely and methodically studied. No sooner was this done however, than we perceived that all the

outcrops of the ore accidently discovered in the formation, belonged to one solid and extensive band regularly interstratified in the lower part of these slates; accompanied by such well marked features in the adjoining rocks as to render the tracing of its course with proper skill and knowledge, a matter of ease and certainty. From the descriptions above given of the several belts of F. VIII. in the long and wide valley of Lewistown, some idea can be had of the truly prodigious body of this ore which remains yet undeveloped. I cannot hope however, to convey to persons not thoroughly familiar with the intricate topography of the region, a correct conception of the range and distribution of that part of F. VIII, in which this ore should be sought until I am enabled to elucidate my descriptions by the requisite maps and sections.

The stratum of ore varies in thickness from three or four feet, to ten or fifteen feet, and lies usually closely contiguous to the calcareous or cement layers of the formation, overlying them only a few feet and being removed from the upper surface of the fossiliferous sandstone F. VII. by from fifty to one hundred feet of strata. Whether it is evenly spread as one continuous deposite from Lewistown to Maryland, or whether it is less constant, thinning away and re-appearing, cannot be determined until its several belts are more explored by those interested in using it. The stratum remote from its outcrop, consists of bands of ponderous bluish grey or lead colored *proto carbonate of iron* sometimes breaking into square masses, and sometimes of a more slaty or laminated structure. It does not effervesce when touched with acid; when roasted it becomes reddish brown and is then strongly attracted by the magnet. The analysis in chapter VI. will display the usual composition of the ore.

It is only where the stratum has been long exposed at its outcrop to atmospheric influence, converting it into the brown *per-oxide of iron*, by which it assumes a wholly different aspect, that it forms the deposite at present worked by the furnaces situated near it. This ore, at its outcrop, is of a dark hazel brown color, a smooth grain, and a cellular structure. That which is derived from the rectangularly cleaving portion of the solid bed, is in square masses, with large squarish cells, often glazed and irridescent on their inner surface, and either entirely empty or partially filled with a pure bluish clay. Sometimes where the bed has been so protected as to escape extensive atmospheric action, this convertion to the brown *per-oxide* is only partial, a solid nucleus of the bluish *proto-carbonate* forming the interior of the lump, while the *per-oxide* occurs only on the surface, in the form of a crust of greater or less thickness. Between this crust and the undecomposed nucleus, the earthy particles, originally in that portion of the *proto-carbonate* which has been converted into the *per-oxide*, having been left by the iron in assuming its new state of concretion, lie loose in the intervening space, forming a dust when dry, and when moist a tenacious clay. This travelling of the atoms of *oxide of iron* from the interior to the circumference of

the mass, in all cases where a *proto-carbonate of iron* undergoes conversion to the *per-oxide*, is a highly curious fact which science has not yet explained.

Distribution of the Ore.

It is probable that this bed of ore extends, either partially or uninterruptedly, for considerable distances in nearly all the synclinal axes where the lower beds of F. VIII. occupy the summits of the sandstone ridges between Lewistown and Shirleysburg. The ore banks at present worked are in these positions. The ore occurs in Little Cove, and, at Pennock's furnace in Huntingdon county, in precisely the same geological relations; but to what extent it prevails throughout the long line of intermediate country, nearly thirty-five miles in length, we have at present no means of ascertaining.

Strata of very analagous ore exist on the flank of Dickey's mountain, near Hanover furnace, and, we have reason to believe, range very extensively in this part of the series. Ore of the same cellular structure as that above described, is visible in a similar position on the flanks of Cove mountain, and on the north flank of Stone mountain. Its place in the strata is a short distance above the thick mass of red shale in the upper half of F. V. It is not to be confounded with the fossiliferous ore, already mentioned, which occupies a lower position, being among the calcareous shales nearer the middle of the stratum.

Iron Ore of F. IV. on Black Log Mountain.

There is a deposite of stalactitic iron ore occuring in a transverse fissure near the crest of Black Log mountain, four miles south-west of Rockhill furnace. The adjoining rock is the upper white sandstone of F. IV. The ore is of a brownish black colour, and of a cellular and stalactitic structure. It is rich, easily reduced, and produces a red-short iron. The rocks of F. IV. here are reddish, being tinged with oxide of iron, the solution of which is probably the source of the deposite.

Formation IX.—*Red Shales and Sandstones.*

At the passage of the underlying olive slates of F. VIII. into the red rock of F. IX. above, we meet with a thick series of beds, composed alternately of the materials of the two adjacent strata. They consist of buff and olive coloured slates, interstratified with reddish slates of very similar composition. They are highly argillaceous but compact, and offer considerable resistance to denudation. They usually form rounded but continuous ridges, more elevated than the neighboring hills of the olive slate, and give rise to a soil which is well adapted to cultivation. Clear ridge in Hare's valley, and Timber ridge on the north-west side of Licking creek, consist of these beds.

Formation IX. commencing over the synclinal axis in the middle of the basin of Great Aughwick valley, near the mouth of Three Spring creek, gradually expands in its course towards the south-west until about eleven miles from its origin it meets the other belt which ranges along Hare's valley, and follows the base and flank of Sideling hill. The two compose then a track several miles broad, in which the anticlinal axis of Jack's mountain gradually flattens down or expires. The strata now gradually assumes throughout, a north-west dip, when the belt contracts and ranges thence, with great regularity, to the south-west, along the base and slope of Sideling hill, until it reaches the Potomac. The sudden narrowing of the belt occurs opposite to a curvature in the anticlinal axis which extends from Black Log valley into Pigeon cove; but the cause of this curvature, and of the diminished breadth of F. IX., is manifestly the sudden subsidence of the Jack's mountain axis of elevation.

Another considerable belt of F. IX., occupies the principal part of Big Scrub ridge, where it supports, in the form of a basin resting on an elevated table land, the overlying grey sandstone of F. X. and the still superior red shales of F. XI. Commencing north of Harshy's mill, in the synclinal axis north-west of Little Scrub ridge, this tract of red rocks of F. IX. immediately widens out, and four or five miles to the south-west embraces the table land of overlaying rocks referred to, which divides it into two nearly parallel zones. That on the north-west, forming part of the licking creek settlement, exhibits the strata at the base and on the north-west flank of Big Scrub ridge dipping thirty degrees to the south-east. The other belt follows the south-east base and flank of the ridge, and has its strata in an almost perpendicular altitude, uptilted by the prodigious pressure exerted along the great dislocation in the formation at the base of Little Scrub ridge. Between six and seven miles from their point of separation, these two belts of F. IX. reunite, the upper harder beds of the stratum forming the summit of Big Scrub ridge for several miles further to the south-west, beyond the termination of the sandstones of F. X.—The whole belt of F. IX., about two miles in width continues towards the south-west until it reaches the Potomac several miles below Hancock—its beds on the south-east dipping steeply north-west, and those on the opposite side gently towards the south-east.

Formation X.—*Coarse Grey Sandstone and Conglomerate.*

This rock, besides forming the summit of Sideling hill throughout its entire length from Terrace mountain at the Juniata to the Potomac, forms the table land of all the central portion of Big Scrub ridge. In this latter mountain, it contains a synclinal axis, and forms, therefore, a trough or basin, which is about six miles long and one wide. Within this basin is a rather curious elevated little valley, the surface of which is about three hundred feet below the crest of the sandstone ridge which every where surrounds it. From the outer base to its summit, Big Scrub ridge is about eight hundred feet high The

beds of conglomerate have a perpendicular dip on the south-east side, and on the north-west a gentle inclination of thirty degrees to the south-east. The little synclinal valley, covered by an extensive meadow, is drained by a defile or gorge in the perpendicular wall on the south-east, where the stream called Tumbling run finds its course impeded by a succession of waterfalls.

Formation XI.—*Red Shale.*

The small valley on the top of Big Scrub ridge is formed by a belt of F. XI., about five miles in length and six hundred yards in breadth, encircled by a perpendicular strata on the east, and more gently sloping ones on the west. This tract is called the "meadow grounds," and is resorted to, at proper seasons, as a natural pasturage for cattle.

The broad valley lying south-east of Sideling hill, from the general poverty of the soils of F. S. VIII. and IX., is a sterile district, thinly settled. Its physical features are those of a rolling, hilly surface.

Iron Ore near the contract of F. IX. and F. X.

Rather more than two miles from the north-east extremity of Big Scrub ridge, a small deposite of iron ore occurs on the north-west flank of the mountain. It is associated with the sandstone which lies but a short distance below the conglomerate belt of F. X., and which form a range of cliffs along all this side of the ridge. Though not abundant, the ore is interesting from its beautiful structure. It is a fibrous, radiated hematite, arranged in parrallel cylinders or stalactitic rods. These cylinders seem all to have been pendent, like icicles. It lies loose at the base of a precipice of the argillaceous sandstone, having apparently fallen out of a cleft or fissure in the stratum.

M'Connelsburg Cove.

This is a little valley of elevation, consisting, in its centre, of F. II., the great limestone formation near the base of our lower secondary series. It is bounded on the south-east by the main Cove mountain, and on the north-west by the Scrub ridges. Nearly opposite M'Connelsburg, Little Scrub ridge, extending from the Burnt Cabins, ends; and six miles to the S. S. W., near Hunter's mill, another ridge, called Dickey's mountain, rises to occupy the same range. These two ridges are prolongations of the same belt of the white sandstone F. IV. which between them has been heaved down to a great depth by an enormous dislocation which extends for at least twelve miles along the north-west side of the cove, burying the strata which ought naturally to occupy the surface under more than two thousand feet of other rocks inverted over them, and bringing, in one place, Fs. II. and VIII. violently into contact.

Limestone F. II. and its Anticlinal Axis.

The limestone of the cove consists of alternating beds of pure blue and siliceous limestones, and whitish magnesian limestones adapted for making *hydraulic cement.* The upper layers, adjoining the overlying slate, embrace dark calcareous slates and black limestones, but without that profusion of fossils which these layers contain where they are exposed in some of the limestone vallies to the north and north-west.

The limestone is traversed by an axis of elevation which ranges somewhat centrally along the valley, and passes directly through M'Connelsburg. Its regularity is somewhat disturbed by the contiguity of the great fault or dislocation on the north-west.

Dislocation along the side of the Cove.

The rocks composing Little Scrub ridge, and ranging along both sides of it, are, for the first five or six miles of its course from the north-east, in their proper relative positions, though slightly overturned or inverted as far to the south-east as the position of the anticlinal axis. Such is the state of things at Harshy's gap. About two miles further to the S. S. W., or seven miles from the Burnt Cabins, the great fault commences, running parallel with the ridge. The adjoining limestone on the north-west side of the cove begins to assume its natural dip towards the north-west, becoming less inclined as we trace it to the S. S. W. Presently, however, the slate F. III. disappears—then F. IV. the sandstone constituting Scrub ridge, dipping now eighty degrees to the south-east. Here all the upper portions of F. V., the limestone F. VI., the sandstone F. VII., and a large part of the slate F. VIII., all vanish—the rest of F. VIII. dipping, like the sandstone F. IV. in contact with it, eighty degrees to the south-east. The strata F. S. II., III., IV., V., VI., VII., and VIII., have all been broken off and heaved down on the north-west side of the fracture, leaving only a wedge-shaped mass of F. IV. composing the remnant of Little Scrub ridge, filling the fissure between F. II. and F. VIII. This unconformable fragment of F. IV. is much shivered and polished by the enormous crushing force to which it has been subjected.

About three miles further to the south-west, opposite to M'Connelsburg, the same condition of things still exist, only the limestone F. II. dips more gently to the north-west, and a larger portion of F. VIII. has been cut off by the fault. Little Scrub ridge ending at this place, the limestone F. II. abuts directly against the slate F. VIII., the latter bounding, in reality, the cove, though the mountain a mile to the north-west, called Big Scrub ridge, already described, is generally considered as the boundary. Tracing the fault for several miles to the south-west, the limestone in contact with it becomes less inclined to the north-west, while the remnant of F. IV. occupies the fissure at intervals, forming at several places a low and obscure

ridge. At Rankin's clover mill, four miles to the south-west, at the termination of Little Scrub ridge, the limestone adjacent to the fault dips to the opposite quarter, or the south-east. From this point two miles south-west, to Hunter's mill, situated immediately on the fault, the same state of things prevails, F. VIII. beginning to emerge. A little south-west of Hunter's mill, the sandstone F. IV. rises into Lowrey's knob, and continues thence to the south-west in a ridge, called Dickey's mountain—the other formations emerging on the western flank of Lowrey's knob. Here Fs. V., VI. and VII. appear in a perpendicular attitude; and along the south-east side of the knob lies a portion of the slate F. III., with its beds in great confusion. At *this* point is a rich and valuable deposite of *iron ore*, attached to Hanover furnace.

The ore lies in the clayey soil over the crushed slate, and seems to have been collected here from the filtration of the ferruginious matter out of the sandstone of the knob which rises close at hand in a steep slope. Opposite to the knob the anticlinal axis of the middle of the Cove disappears being obliterated by the upheaving of that part of the limestone which lies south-east of the fault. Further towards the southwest, the dislocation becomes itself an anticlinal axis, the same which elevates the strata in the south-west end of the Cove. In this part of the Cove, the rocks on the north-west side of the axis are perpendicular while those on the south-east side incline gently towards the base of the Cove mountain. The limestone beyond this is overlaid across the axis by slate which forms the head of the valley towards the south-west, which is soon after closed by the union of the Cove and Dickey's mountains.

F. III. Slate.

The slate F. III., is a stratum of considerable thickness in the Cove, covering the north-east end of the valley for several miles, the belt dividing where the limestone is protruded to the surface. The western belt keeps along the base of Little Scrub ridge until it is lost in the fault. The eastern one bordering the Cove on the flank and at the base of Cove mountain is nearly half a mile in breadth. It dips uniformly to the E. S. E. thirty degrees, and ranging southward meets the western belt which emerges from the dislocation near Hunter's mill, and ranges about three and a half miles to their junction. After their union, the general belt of slate covers the southern end of the valley called the *corner* of the Cove, for three miles. In consequence of the profusion of the debris from the adjoining sandstone mountain, which here forms the soil, this part of the valley, is almost incapable of cultivation.

Iron Ore of F. III.

The ore bank of the Hanover furnace occurs on the south-east side of Lowry's knob, just where the slate F. III. emerges from the

Scrub ridge fault. The slate is much contorted, and crushed in places into a clay into which the ore has been lodged. At the outcrop the ore formed a thin waving layer which traced into the side of the hill assumed a perpendicular direction and became much thicker. It lies surrounded by clay, that beneath it being very unctious and beautifully colored. The ore is much used. It occurs ofted in angular masses of considerable size, having a fracture or cleavage similar to that of the adjacent clay. It is compact and ponderous, has a dark reddish brown color, and is as rich as the *hydrated brown ores* generally are, which are derived from this formation. Its aspect and composition are however somewhat variable. Smelted with the cold blast it makes a good malleable iron a little *red short*, or not welding with facility at a red heat. The analysis in chapter VI. will display the average composition of this interesting ore.

The clay underlying it is different from that above it, being almost impermeable to water, and hence the effectual manner in which it has arrested the *oxide of iron* percolating from above.

Formation IV. White Sandstone.

In the Cove mountain and neighbouring ridges, F. IV. does not retain the tripple subdivision to the extent which it exhibits in the mountains further to the north and north-west, and hence we do not find its ridges here, possessing the double summits which characterize those of other districts.

Little Scrub Ridge, commencing in Sidney's knob at the Burnt Cabins, is there of the usual elevation of the mountains of F. IV., but advancing towards the south it declines in height and assumes an undulating summit. This is in part owing to the increasing steepness of the strata. The belt ends as before described by disappearing in the fault opposite M'Connonelsburg, and appears only at intervals in three or four places for six miles to the south, lying as a detached mass in the fault. Reaching the surface again in Sidney's knob, the sandstone soon swells into a mountain of considerable height, which reaching the Maryland line sweeps eastward and terminates in the end of Cove mountain.

The Cove Mountain, commencing at Sidney's knob, bounds the eastern side of the Cove, and runs in a nearly straight line south, until opposite M'Connelsburg, embracing between it and the southern continuation of the Tuscarora mountain a norrow trough or synclinal axis which there closes up. Beyond the junction, the mountain sweeps to the south-east, the Chambersburg turnpike ascending its flank. By the curve in the mountain, the Cove is considerably widened. Near the curve terminates the anticlinal axis of the Tuscarora mountain. The Cove mountain now assumes its proper direction to the S. S. W., and gently curving south and then westward finally unites with Dickey's mountain not far from the State line. Its rocks dip uniformly towards the E. S. E. thirty degrees.

About two miles north of Louden, a synclinal axis or trough originates on the eastern side of the Cove mountain in F. IV. Expanding towards the south, this trough becomes the basin called the Little Cove, the western ridge of which runs south, as the prolongation of the Tuscarora and Big Cove mountain, and the other running S. S. W., becomes the Little Cove mountain, bounding the valley west of Mercersburg. The formations together with their ores which compose the Little Cove basin have been already described with sufficient fulness for the present

SECTION III.

Kishicoquillas Valley.

Kishicoquillas valley, the next belt of country towards the north-west, beyond the Lewistown valley, extends through parts of Mifflin and Huntingdon counties, from north-east to south-west, having a length of nearly thirty miles, and a breadth varying from two to four miles. Nearly the whole area of the valley consists of fertile land, some of which is under high cultivation. It is a beautiful instance on a large scale of what is termed in geological language a ***valley of elevation***. The bed of the valley consists of Fs. II., and III., uplifted to the surface by several anticlinal axes and the whole bounded by mountain ridges composed of the less destructible sandstones of F IV. The surface of the valley in its highest portion around Allenville, is elevated three hundred and fifty feet above the Juniata, at Lewistown. It descends gently in all directions from this central district. Two deed gorges or gaps in the belt of mountains which encircle it, admit us into this valley. One of these called Brown's Gap, is in Jack's mountain, its general south-eastern boundary. Through this passes Kishicoquillas creek. The other Gap is in Stone mountain, which encompasses the valley on the north-west. This is at its eastern extremity, and affords an outlet for Goslin run. The two mountains which confine the valley are ***Monoclinal Ridges***, that is to say their strata dip in but one direction, those in Jack's mountain dipping to the south-east, and those in the Stone mountain to the north-west. After ranging for many miles to the south-west, and gradually converging, these mountains fold together over the anticlinal axis of the valley, and thus shut it up. The anticlinal axis then ranges along the summit of Jack's mountain to its termination near the Three Springs in Huntingdon county.

Limestone F. II.

The lowest strata of the great limestone formation which have been brought into view near the centre of the valley, by uplifting agencies, consist of blue limestones, some pure and some siliceous, alternating with lighter coloured greyish-blue magnesian limestones, nearly of the composition called dolomite. A little higher in the

formation, these magnesian beds constitute a thick belt; while above them, bluer and more purely calcareous limestones succeed, supporting, in their turn, a mass of dark argillaceous limestones and nearly black calcareous slates, the latter often highly fossiliferous. These upper layers mark the passage of the limestone into the overlying slates of F. III.

Slate F. III.

The slate F. III. encircling Kishicoquillas valley ranges in two belts. That on the south-east follows the base and slope of Jack's mountain, spreading usually from the ridge a few hundred yards into the valley and rising more than half way up the acclivity. The other belt, on the north-west, leaving the subordinate vallies between the knobs at the north-east end of the principal valley, ranges along the base of the Seven mountains, and then along that of Stone mountain, until it meets the other belt connected with Jack's mountain, when the two occupy the south-west end of the valley for more than a mile. The slate again shows itself on the Juniata, at Drake's Narrows, four miles beyond, having passed out of Kishicoquillas valley under the axis of the mountain. Opposite Greenwood, the slate expands further into the valley, in consequence of a dislocation of the strata in Stone mountain. This part of the belt, several miles in length, is three-fourths of a mile broad. Further to the south-west, it resumes its usual position near the base of the ridge, but extends high up its slope owing to the gentleness of the dip. Still further to the south-west, it becomes perpendicular; and about seven miles beyond Allenville, joins the south-eastern belt over the anticlinal axis.

At its north-eastern extremity, Kishicoquillas valley is subdivided into three lesser vallies, by the commencement of two synclinal ridges, locally called knobs. One of these little vallies destitute I believe of a name, lies between the Seven mountains and Baird's knob, and is prolonged to the north-east between the former range and Stewart's knob. The central one lies between Beattie's and Stewart's knobs, and is called Orr's valley. The third or most south-eastern is included between the southern or Beattie's knob and Jack's mountain. These conspicuous knobs are high ridges of regular synclinal structure, appearing, when seen from a distance, to consist each of a high central ridge and two outer ones in the form of broad and very regular terraces. The northern knob, called Stewart's, is on the same range with Baird's knob, the two occupying one synclinal axis.

The limestone ceases about one hundred yards south-east of Greer's tavern, and about five hundred yards from the base of Jack's mountain. Its north-western margin is near the furnace and a little south-east of Thompson's tavern. The formation extends to the north-east a short distance beyond Sterrett's mill, where the upper or fossiliferous layers show themselves. The limestone itself is not developed in the small valley between Jack's mountain and Stewart's

knob. It sweeps round Beattie's knob, and in a rather narrow belt ascends Orr's valley to within one mile of Mr. Solomon Close's, the last farm house between the knobs. It does not pass round Stewart's knob, as the synclinal axis of that knob carries a trough of slate throughout the whole distance between it and Baird's knob, south-west of the turnpike. The only part of F. II. developed in the valley to the north-west of this synclinal axis, is the fossiliferous portion, consisting of the uppermost layers which are well exposed on Mrs. Christman's farm.

Anticlinal Axes of the Valley.

The axes which have protruded the limestone to the surface, are not of that symetrical structure found in vallies of elevation of a simpler form; for instead of the strata dipping in both directions away from the central line, the two sets of dips are often towards the same quarter, those on one side of the axis being *inverted.* This inversion occurs almost in every instance on the north-west side of the anticlinal axes. Even when a part of the strata have not been averted near an anticlinal axis, those on the N. W. exhibit with a few exceptions, a steeper dip than those on the S. E. These striking features point to something very peculiar in the mode in which our rocks have been elevated by subterranean forces and seem plainly to indicate that the uplifting pressure was not strictly vertical, but exerted, from the N. E. toward the S. W. The probable cause of this will be discussed in my final report.

An anticlinal axis traverses the little valley between Jack's mountain and Beattie's knob. It dies out between four and five miles north-east of the turnpike. Another anticlinal axis follows near the middle of Orr's valley between the two knobs, being visible on the main road leading up this valley, as far as the uppermost *sink hole.* This axis is prolonged to the southwest, passing, apparently one-third of a mile south-east of Perryville. A third anticlinal axis ranges immediately to the north-west of the last and parallel with it, running also to the mouth of Orr's valley or to the south-east of Stewart's knob. The rocks on the north-west side of this axis show an inverted dip or incline to the south-east. This is clearly seen on a farm half a mile east of Perryville, where the beds on the south-east side of the axis incline thirty degrees to the south-east; and those on the north-west, seventy-five degrees to the south-east. The very line of the axis is discernable in a broad *sink hole* immediately north of M'Dowell's house. It probably dies out in Orr's valley about one mile above its mouth. This last axis, extending along the north-west side of the general valley near the base of Stone mountain, terminates a short distance south-west of Sinkey's gap.

On the south-east side of the valley, another more extensive line of elevation in the limestone commencing three miles south-west of Brown's Gap, and extending to the south-west, becomes the main central anticlinal axis of the valley, and afterwards of Jack's

mountain in Huntingdon county. The ends of this axis and that before described as lying near the base of Jack's mountain pass each other, the overlapping extremities being nearly two miles apart. Between these extremities terminate the two other axes first described, that of the Little valley south-east of Beattie's knob, and the south-eastern or longer one, of Orr's valley. The anticlinal axis nearest to Stone mountain, has its strata on the north-west, overturned as already mentioned. The main axis nearest to Jack's mountain extends for many miles parallel to its base from which it is about a mile distant. To the soth-east, of Greenwood, it exactly coincides with the line of valuable *ore banks*, and at Allenville shows itself about midway between the town and the foot of Jack's mountain. It ranges regularly on towards the S. W. between four and five miles, preserving a uniform and moderate inclination in the strata on both sides of it until the gradual bending round of Stone Mountain brings it against its base. Here it assumes a sudden change of direction, curving towards the S. S. W. to run parallel with the foot of that ridge. The rocks on the N. W. side of the axis previously at a gentle dip, now become perpendicular, and continue thus to the termination of the valley, when it passes under the summit of a broad and lofty ridge formed by the union of Jack's and Stone Mountains.

Iron ore of Kishicoquillas Valley.

The iron ore of this valley is the usual cellular and stalactitic brown ore of the limestone districts. It occurs in irregular nests and layers in the ferruginous loam and clay overlying the limestone to which it seems to bear no fixed relation. Its discovery is therefore a matter almost entirely empirical. In Kishicoquillas valley, however, its distribution is so dependant on the geological structure of the belt, that its range already ascertained by excavations, can be laid down with great precision. All the ore deposites hitherto wrought *occupy the lines of elevation* of the limestones, occupying exactly in the fissure formed by the angular bending of the strata, over the anticlinal axes. It seems probable that no valuable body of ore has been deposited in any other position in the valley. Immediately upon the anticlinal axis which comes out of Orr's valley, and becomes the second one south-east of the foot of Stone mountain, there is a considerable deposite of *iron ore* wrought at Davis's bank. But it is in the fissure of the main axis or that nearest Jack's mountain, that the best ore deposites lie. A little south-east of Greenwood, there is a line of excavations from which large bodies of ore have been taken. The principle banks are those of Messrs. Holliday, Hall and Rawle, and Patton & Co. Little doubt can be entertained that ore of the same quality exists at various other points on the line of the anticlinal axis, both north-east and south-west of these openings. Promising indications of the ore were witnessed on several farms precisely in the range, as ascertained from other independent proofs, of the fissure along the line of the axis.

The evidence of the existence of ore in sufficient quantity towards

the north-east end of the valley are by no means obvious, only a single bank being extensively wrought. This lies about four miles from Perryville, on the farm, I believe, of Mr. Samuel M'Nitt. Its position is upon the crushed anticlinal axis already described, as terminating near the mouth of Orr's valley. This ore is no longer used, owing to too large a quantity of *sulphuret of iron*, which is intermixed with it. I conceive that though the promise of ore in this section of the valley is not inviting, the best chance of obtaining it, is in the line of country immediately contiguous to the range of the crushed anticlinal axis which extends from M'Nitt's to Perryville.

Formation IV.—*White Sandstone.*

This stratum retains its triple character in the mountains bounding Kishicoquilles valley, though less distinctly than in the ridges further towards the north-west. The softer and more argillaceous nature of the middle member of formation has given rise by denundation to a bench or elevated terrace on the flanks, not only of Jack's and Stone mountains, but also of the knobs. This has been erroneously conceived by some to mark the shores of a supposed lake, of the existence of which we have no evidence whatever.

Stone mountain, has a sharp narrow and regular crest throughout the greater part of its length. A notch, or depression in the ridge between three and four miles south-west of Milligan's knob, is called Sinkey's gap. The terrace on the side of the mountain from this gap for several miles to the south-west, is about a fourth of a mile wide, and is trenched by a number of deep ravines on the flank of the mountain. It becomes wider near a great fracture in the chain opposite to Greenwood. This fracture or fault occurs where the road leads across from Greenwood into Stone valley. The main crest of the mountain consisting of the upper member or white sandstone of F. IV. suddenly ends, and another ridge, the crest of which is formed by the same upper sandstone, dipping in the same direction, steeply to the north-west, commences northwest of the former at Greenwood furnace. This latter mountain continues south-west as the main Stone mountain, its terrace soon becoming regular and nearly a third of a mile wide. The two crests of the dislocated ridge pass each other, overlapping nearly a mile and a half. The line of dislocation intersects the mountain obliquely, having a N. N. E. and S. S. W. direction, and the rocks to the north-west of it have been heaved up past those on the south-east, so as to dip in the same direction—it is only towards the south-western end of the fault, that the strata on the south-east side dip away from the dislocation. Beyond Allenville to the south-west, the terrace on the flank of the mountain becomes three-fourths of a mile broad. The Rocks of the Lower sandstone division F. IV. form the brow of the shelf, with a less steep inclination than those of the upper division in the crest of the ridge. Still further to the south-west towards the termination of the valley, the rocks becoming more perpendicular, this terrace grows proportionately narrower, and is at last hardly perceptible.

Jack's mountain, bounding the valley on the south-east side displays great regularity in its contour. Its crest or summit is nearly straight, consisting like that of the Stone mountain, of the upper hard sandstone of F. IV. Its strata, generally incline to the south-east, very uniformly at thirty degrees dip. Towards the south-west the mountain gradually sweeps round more to the south, making a convex curve on the side next the valley. Its terrace usually between three hundred and four hundred yards broad, widens near Allenville, and becomes gashed by deep ravines, exhibiting great uniformity of outline, at distances averaging a third of a mile. Beyond the point, where it coaleces with Stone mountain, the ridge assumes the anticlinal structure, though the rocks of the opposite flanks retain nearly their previous dip, that prolonged from Stone mountain, forming the north-west side, being nearly perpendicular; while those continued from Jack's mountain slope to the south-east, at an angle of twenty-two degrees. The broad and majestic ridge thus composed, traverses Huntingdon county, and terminates near the Three Springs, undergoing a gradual flexure to the south as it proceeds.

The next belt of country, proceeding to the north-west, is that of the Seven mountains; but as a general discription of this wild unpopulated district, was given in my last annual report, and as a detailed and full account of it can only be rendered intelligible through the assistance of a geological map and sections, I deem it best to postpone publishing the result of our examinations until the appearance of my final report. I shall therefore offer some details, intended to show the resources and structure of Stone valley, and the general belt of formations ranging from the Seven mountains to the south-western side of the Juniata.

Stone Valley.

It will be convenient for the sake of brevity, to extend the name Stone valley to the whole district embraced between Stone or Jack's mountain and Tussey's mountain, as far to the south-west as the Juniata, though that portion which lies between Warrior ridge and Tussey's mountain, is sometimes called the valley of Shavers creek. This subordinate valley, extending to the south-west side of the Juniata, assumes the name of Hartzlog valley, and afterwards, from the knob of Tussey's mountain, five miles from Alexandria, onward to the south-west, it takes that of Woodcock valley.

Confining our attention for the present to the general valley north-east of the Juniata, we may consider it as one broad basin traversed by a principal synclinal axis, extending from the coal basin of Broad Top mountain, through Terrace mountain, and through this valley, and finally through Milligan's knob, and thence by Stewart's knob to the Susquehanna. The slate ridges, which range from the south-west, following, respectively, the bases of Terrace mountain and Sideling hill, unite in the central part of what we term Stone valley. Outside of these, Warrior ridge and Rocky ridge, form two belts of the

sandstone F. VII. and unite like the slates, but at a point further to the north-east. Encircling the sandstone of these ridges, are the next lower rocks of F. VI. and F. V., ranging together in a belt along the base of Stone mountain and at the foot of Tussey's. These, by their union, form the head of the valley, F. V., folding over the spurs prolonged from the chain of the Seven mountains.

The only portion of the district, which requires from its intricacy, a minute and detailed investigation, is the belt composing the Warrior ridge and the valley between it and Tussey's mountain. This part is traversed by many parallel and even overlapping axes of elevation. F. V., folded round most of these axes, the *fossiliferous iron ore* is brought to the surface, and therefore much research has been necessary in tracing the exact features of this section of the valley. The general synclinal axis of Stone valley, lies about four and a half miles from the foot of Warrior ridge, and two and a-half from that of Rocky ridge. The inclination of the strata on the two sides of this axis, is nearly equal, being not more than from ten degrees to fifteen degrees. Further to the north west, the dip augments to twenty-five degrees, and again diminishes as we approach Warrior ridge, it being about five degrees where the Juniata intersects the sandstone. On the other side, towards the north-east, it becomes thirty-five degrees as we recede from the middle of the basin to the first hill, parallel to Sideling hill; while in the next belt of slate hills, belonging to F. VIII., the dip to the north-west becomes seventy degrees, and at the Gap in Rocky ridge, the sandstone F. VII., is nearly perpendicular.

The physical features of Warrior ridge, are somewhat peculiar, though its structure is simple and easily explained. Opposite Huntingdon and Petersburg, it is a broad table land, the sandstone F. VII. capping its summit. Along the top of the ridge and in many places at its flanks, it is gashed by deep ravines. The strata are not quite uniform as to dip, undulating gently in consequence of the dying out of some of the axes of the Seven mountains. Towards the north-east, the dip augments, and the ridge accordingly becomes narrower, the sandstone occupying then only the south-east half and the underlying limestone, F. VI., the north-west. Formation VII., curves round to meet the corresponding sandstone of Rocky ridge, about sixteen miles north-east of Huntingdon; from the Juniata, Warrior ridge contracts in breadth also towards the south-west, its strata here being beyond the influence of any axes tending to hold them up in a wide belt.

The several formations, occupying the broad basing before us, are so analagous in aspect and composition to the belts of the same already described in the Lewistown valley, that a passing notice of them in this place will suffice. Formation IX., consists of red sandstone of various shades of colour, alternating with layers of red shale. Formation VIII. embraces much grey sandstone, and towards its upper portion, some beds of a very massive greyish blue variety. These last are quarried near the canal below Huntingdon, and supply an excellent building stone. Beds of superior flag stone occur in the al-

ternation of F. VIII. and F. IX. The general character of F. VII. is that of a white course sandstone, which readily disintegrates by exposure. The roads on Warrior ridge are frequently covered with sand to the depth of several inches. The sandstone being intersected by a system of regular and extensive joints in plains nearly perpendicular to the bedding of the rock, and being at the same time thus easily weathered, its blocks sometimes assume singular and grotesque forms, standing forward in crags or rising in remarkable columns. The Pulpit Rocks, near Huntingdon, are an instance of the joint operation of the two causes mentioned.

Some of the beds of this formation, furnish a material admirably fitted for the hearth stones of blast furnaces. The hearth stone of Mill creek furnace is procured from Rocky ridge.

The limestone F. VI. possess very nearly the same features which distinguish it in the Lewistown valley. An ash-colored and very argillaceous variety occurs near its passage into the underlying shales of F. V. This is not adapted either for burning for lime, or for building with. When newly taken from the earth, it has a rather durable aspect, which has occasionally deceived the engineers who have used it in the construction of aqueducts, and other important structures on the canal. It is well exposed three hundred yards below the forge at Petersburg. These alternating rocks between F. V. and F. VI. are very thick, and comprise many of the hills north-west of Warrior's ridge. When tracing the *fossiliferous iron ore* of F. V., I shall allude to the beds of that stratum, more particularly of the portion connected with that valuable layer of *iron ore*. Formation V. occurs in the flank and at the base of Stone mountain, where, however, the ore bearing portion of the rock does not form a distinct ridge. The belt continues for nineteen or twenty miles to the north-east from the Juniata, and then expands from the head of the basin between the Stone and Broad mountains. Ranging north-east of Greenwood furnace, it folds round the end of Broad mountain, taking an anticlinal form which throws up the ore in a chain of elliptical hills, where it is dug at the ore banks of Messrs. Alexander and Diarmid. In this manner it winds round the end of all the ridges of F. IV. between Broad mountain and Tuseys mountain, making its south east boundary the north-west base of Warrior ridge, and then occupies the valley of Shaver's creek, and its continuation to the north-east, ranging also to the south-west into Hartzlog and Woodcock vallies. This wide belt embraces many anticlinal axes, between which lie the rocks of F. VI. and F. VII. These spread out the formation in many changes of dip, causing chains of hills, in which the fossiliferous ore crops out upon the surface.

Iron Ores in Stone Valley.

About one mile south-east from Mill creek furnace, a deposite of ore occurs overlying F. IV. on the summit of Jack's mountain, which deserves mention from its peculiar position. From the ore digging, a

ravine runs up the slope of the mountain towards the east, on the north-west side of which occurs a ridge, embracing the upper sandstone of F. IV. The ore is on the very edge of the summit of the mountain, where it has been reached in a shaft of some depth, which terminates in a sandy clay containing the concretions. Reflecting on the circumstances which have given rise to this deposite, one can hardly resist the persuasion that a large bed of ore in this situation is rather improbable, and that its present sandy character will not give place to a purer one, when the mass shall be penetated deeper.

The fossiliferous ore of F. V. merits much more attention, and deserves a diligent examination by mining, on the part of those interested in this valuable mineral. Though only one or two openings have hitherto been made in the bed, our efforts to trace it were in some degree crowned with success, owing to the useful clue afforded by a previous investigation of the range of the several axes or lines of elevation, and of the precise place in the formation to which the ore appertains.

The lower shales of F. V. are olive and yellowish; those adjacent to the ore are of a deep buff color. Over these are layers of a hard white or greyish-white sandstone, breaking into rhomboidal fragments. This rock, which is not always present, is distinguished by its abundance of fossil *encrini*. Its thickness is less than in the Lewistown valley, but its fragments are more scattered at its out-crop at the surface, in consequence of its inferior hardness. The weathered pieces have a rotten, worm-eaten aspect, and a dirty yellow color.—This rock is well known throughout the valley, and I therefore wish to attract especial attention to it as the best guide I can suggest to the position of the ore. It will be remembered that in the Lewistown valley a similar encrinitic sandstone occurs invariably just below the ore; here, on the other hand, it seems to *overlie* it. The reverse of this order of things prevails, however, at one of the excavations undertaken for Messrs. Dorsey and Green, not far from the passage of the Little Juniata through Tussey's mountain, the ore here seeming to rest above the sandstone, as in the Lewistown valley. The ore has been opened to the north-east of Dorsey's forge, in the south-west flank of a hill running parallel to Tussey's mountain, in strata dipping twenty-five degrees to the south-east. The bed is nearly eighteen inches in thickness, and the ore is of the hard calcareous variety. It shows the usual rectangular fracture, and is of excellent quality. The analysis to be found in Chapter VI., will show its composition.

Directly under the ore lies a bed of olive colored slate, supported by a massive stratum of hard encrinitic sandstone. Higher in the same hill, the weathered fragments of the sandstone are abundant. The position of the seam of ore is not favorable to its being easily excavated, and the narrowness of the summit along which its out-crop lies, preventing a sufficient percolation of water, has caused the ore to retain its original compactness and calcareous nature, even near the surface where usually, under more propitious circumstances, the ore is soft and porous.

On the same ridge with the above, between the Little Juniata and the Pennsylvania canal, Messrs. Dorsey and Green have made three or four openings, The most important is the one furthest north-east, where the vein is *a foot thick*, exhibiting some variety in composition and hardness; the hard *calcareous variety* lies above, then another less hard, and a third kind which is quite soft, apparently resulting from the decomposition of the harder variety, succeed. Under this seam occurs the massive *encrinitic sandstone*, occupying a different position from that which it usually observes further to the north-east in this belt. The dip being steep, the most eligible mode of mining it would seem to be to cut a tunnel to it from the base of the hill. Dr. Dorsey has excavated for the ore along the base of Stone mountain, and finds it of insufficient thickness to be valuable. It has been partially opened on the canal, where it is four inches thick, dipping seventy-five degrees to the north-east, and separated from the red shale in the upper division of the formation by two hundred and twenty-five feet of olive, buff and other colored slates. It has been opened elsewhere in the same range, at points where its thickness continues inconsiderable.

Further towards the north-east, the fossiliferous ore has been developed by Messrs. Alexander and Diarmid, in a hill of F. V., which terminates near the furnace, and which curves westwardly and joins another hill on the opposite side of the point of Broad mountain.—Where the stratum expands at the junction of these two hills, the ore has been opened. Fragments of the ore occur abundantly on the surface, but the seam is not visible in several little shafts which were dug a considerable time since. The presumption is, that the bed, if reached at all, proved too thin. At this place the ore probably overlies the buff shales, visible in the shafts. On a road crossing the hill, and at a lower level than these excavations, the ore bed has been opened, dipping nearly to the west; at one spot, where the bed reaches the surface, it appeared, when fairly developed, to be two and a-half feet thick, though at a place thirty feet from this, where it lies under a deeper cover, it is about twenty inches in thickness. The ore at this place is certainly of excellent quality, containing much of the softer variety, near the outcrop, in consequence of the gentleness of the dip, which does not exceed fifteen degrees to the west. The above openings, constitute the only localities in the valley where the ore has been dug, though we have traced it in many places on the surface, where the indications are favourable, both as to quantity and quality, taking care in all cases to direct the attention of the owners of the tracts to its concurrence. The localities will be mentioned in another place.

The openings made by Dr. Dorsey are the only ones where the ore was detected along the base of Jack's or Stone mountain. The anticlinal axis of Broad mountain prolonged, has caused two hills which contain the ore. It is only at the junction of these that the ore has hitherto been opened; but as these hills continue on both sides of the end of Broad mountain, there is no doubt that the ore can be

found in other places on these hills to the east and north-east of the present excavations. The southern hill terminates at the furnace, and it is doubtful whether the ore continues thus far, the strata having been much cut away by denudation. The range of the northern hill is not easily traceable.

The anticlinal axis of the spur of the Seven mountains, next north-west of Broad mountain, in entering the valley, throws up a hill of P. V., disclosing the ore near Mr. Cornelius Davis's. It continues at the surface but for a short distance. No fragments of the ore itself were discovered, but the encrinitic sandstone, and also the olive slate, both indicative of it, are visible. The indications at this spot authorize a search for the ore. The anticlinal axis above mentioned, extends into the limestone of Warrior ridge. The next mountain spur on the north-west, which we shall call the Bear Meadow mountain, divides into three ridges, each containing an anticlinal axis. That next the south has elevated the ore which may be seen a little south of Mr. George M. Bell's saw mill, and which continues thence about a third of a mile north of Ennisville, and directly north of Salsburg. Information that it contained the ore, was important to the proprietors interested, though no particular localities were found where the ore was abundant on the surface; the strata here dip to the south. No difficulty need exist in recognizing the hill, as it is well marked by a profusion of fragments of the *encrinitic sandstone*, in a much weather eaten condition. No prominent hill is here visible corresponding to this, containing the north-west dipping strata of this axis. The same difficulty occurs in tracing the ore hills related to the middle axis of the Bear Meadow mountain, at least none are visible along a section from Ennisville to Steffy's tavern. Crossing the rocks south-eastward, however, a long another line extending from a group of houses, three miles north-east of M'Murtrie's tavern, we detect the encrinitic sandstone. At this anticlinal axis, it is very doubtful, however, whether the ore itself extends thus far. The same axis is observed in the red and green shales above the ore, in a section made south of M'Murtrie's house, beyond which it ceases. The next axis of elevation, is that of the north-western spur of Bear Meadow mountain; this has uplifted the ore in a hill easily recognized. It is about one mile from Steffy's tavern, and has a small shanty at its northern base. Many specimens of the ore were found of a moderately good quality, in an open field belonging to Mr. Steffy, to whom it was pointed out. The same ore is found on the land of Mr. Thomas Blair, a mile and a half from Steffy's, apparently in the same range. It is seen again in the same ridge, a fourth of a mile from Blair's on the farm of Mr. Starr, and might readily be traced through other farms along the ridge, by observing carefully the indicating rocks. Another ore ridge occurs on the north side of Mr. Jonas Rudy's farm, at a little burial ground. This probably unites with the one above mentioned, when the two hills continue as one, passing a few yards south of M'Murtrie's tavern, and dying out between three and four miles further to the south-west. Appearances indicate that the ore is not prolonged as far to

the south-west, as where our section crosses the strata, two and a half miles north-east of M'Murtrie's. A few judicious excavations would determine this point.

The next prominent hill containing the ore, runs north of Mr. Jonas Rudy's farm, passing Mr. William Johnson's house, and extending a short distance south of Mr. M'Mahen's, four and a half miles east of M'Murtrie's. It is traceable eastward in the form of an anticlinal hill, to the road leading from Steffy's to Pinegrove, where it divides, the northern spur passing through Mr. Lighteren's land, and the southern running immediately north of Mr. James Leonard's. The axis itself is prolonged into a short ridge of the sandstone F. IV. Throughout most of this part of the belt of F. V. the ore may be sought for with a fair prospect of success.

The next ore hill commences, on Mr. Maffit's place, north of the one last mentioned, his fields showing an abundance of moderately good ore. The belt ranges along the flank of a ridge of F. IV., and extends through Mr. Robert Moore's farm, and thence along the flank of Stoney ridge through lands of Mr. Roberts, the ore appearing in the soil in both places. This ore ridge is joined by another ranging along the north-west side of Stoney ridge, the axes of the two ridges united, being visible in a section from Dorsey's forge to Petersburg, on the east side of the Little Juniata.

The next exposures of the ore are in some low and indistinct hills connected with *Round Knob*, which rises north-east of the forge.— The belt in which the excavation here made occurs, is that on the north-west side of the anticlinal axis of *Round Knob*. This range of ore extends with occasional interruptions along the summit of a ridge of the encrinitic sandstone, which traverses Hartzlog valley, running through a farm belonging to Governor Porter, and thence into Woodcock valley. The information imparted to the proprietors of lands containing this valuable bed of ore, concerning its exact position and range, will incite them, it is hoped, to search for it by actual excavations.

Another but unimportant seam of ore, occurs higher up in the beds of F. V. It has already been alluded to, when treating of the fossiliferous ore of the formation in Lewistown valley, but neither there nor in Stone valley does it promise to be of any value.

Iron Ore in the Limestone F. VI.

Attempts have been made to procure a supply of ore from the limestone belt at the base of Warrior ridge, especially by Mr. Diarmid.— The ore scattered on the surface, resembles somewhat that near the top of Jack's mountain. Some specimens procured from a shaft, seventy feet deep, sunk through sand and clay, were tolerably good; but neither the structure of the ridge, nor the nature of the overlying soil, warrant high expectations of our finding here a useful deposite of good ore. On the same ridge, not far from Couch's forge, fragments of ore of small size are abundant on the surface, and several shafts

were at one time dug on a farm belonging to Mrs. M'Gill, but without success. The promise of a deposite of ore of any magnitude in this belt of limestone F. VI. is by no means encouraging.

Clay.

In addition to the ore on Diarmid's place, there is a stratum of white clay, which, according to experiments, seems to answer for the manufacture of fire-brick and crucibles. Specimens were presented to the State cabinet by Mr. Diarmid. It lies in a ravine running transversely to the course of Warrior ridge. Its cover is chiefly sand, derived from the disintegration of the sandstone F. VII.

Section IV.

Of the belt of country lying south-west of the Juniata, and between Jack's mountain, and Tussey's mountain.

The next district to be described is the prolongation of the wide belt of the formations which terminate in Stone valley. By the interposition of Sideling hill and Terrace mountain, which terminate together in a high synclinal knob on the south-west side of the Juniata, the general belt before us is divided into three parallel lesser vallies, known as Hare's valley, Trough Creek valley, and Woodcock valley. One principal synclinal axis, traversing the middle of these, or the valley of Trough creek, the same formations rise to the surface in the two opposite vallies of the belt; that is to say, in Hare's and Woodcock vallies, the same rocks dipping to the north-west in the former, which incline to the south-east in the latter. The geology of these two exterior vallies is therefore very similar, while their general structure is remarkably simple. That of Trough creek, on the other hand, is more diversified, and becomes highly interesting when we enter the Broad Top coal basin, which occupies its centre. After devoting a few remarks to Hare's and Woodcock vallies, I shall proceed to describe Trough creek valley, and a portion of its coal field.

Hare's Valley.

The above name is given to the narrow belt included between Sideling hill and Jack's mountain, ending at the Three Springs. Its features are remarkably simple and regular. Sideling hill bounding

it on the W. N. W. is a straight ridge of even summit, the outline of which, for many miles from the Juniata, is scarcely varied by a depression. Its eastern side is usually steep, consisting of the red argillaceous sandstone F. IX. for a considerable height. The summit and north-western slope, are formed of the harder grey sandstone, F. X. Clear ridge consisting of the slate, F. VIII., extends continuously through the valley. Its north-west side from the base half way up, is occupied by the lower beds of F. IX., F. VIII. spreading from this margin to the base of Rocky ridge, which is composed of the fossiliferous sandstone F. VII. The little valley between Rocky ridge and the base of Jack's mountain includes the limestone F. VI., and the red and variegated shales F. V. The limestone F. VI. is quarried in a few places; and it may be useful to offer a few hints at present, respecting the position of the purer varieties of the rock. At a quarry about one hundred feet from the east base of Rocky ridge, and near Mr. Humphrey Chilcoat's, the beds exposed, are rather siliceous and abound in fossils. The rock exhaults a fœtid odour when struck. One bed here is of a purer quality. These layers occur near the base of the sandstone F. VII., the purer portions of the limestones lying from twenty to fifty feet further east from the base of Rocky ridge.

Another quarry owned by Mr. Jacob Crotsley, about five miles south-west from Chilcoat's, holds the same position and displays nearly the same layers. In the neighborhood of the present quarries, the underlying layers, it is true, could not be readily reached, but between Chilcoat's and Crotsley's, spots could be selected where they would be accessible.

F. V. and Iron Ore.

No ore is observable in any part of the belt of red shale F. V. until we approach the end of Jack's mountain, where two hills containing the fossiliferous ore arise. That towards the north-west, is crossed by the road leading from Three Springs to Bell's furnace.

The limestone layers of F. V., were only found in one locality, which is in the neigborhood of Three Spring creek, where they are fully developed; some of them consist of good limestone adapted to making lime; others have the siliceous character usual in these beds.

Formation VIII.

Layers of a blue calcareous sandstone passing into a siliceous limestone, occasionally fossiliferous, occur in the lower portion of F. VIII., on the Juniata. This seems to be the representative of the *cement layers*, found in other belts of the formation. A similar bluish calcareous rock, too impure, however, to furnish lime, may be seen on Mr. Crotsley's farm, between his house and Rocky ridge.

massive quartzose, white sandstones, stained superfically by iron. Nearly all the rocks of F. X. are more or less ferruginous, containing many specks and blotches of the peroxide of iron, from which certain deposites of ore may have been derived by filtration. In these sandstones we occasionally find small plates or patches of genuine coal, rarely of greater superficial extent than the area of a single flattened stem or leaf of some fossilized plant. We also met with a little black slate. Ascending towards the contact of F. XI., the sandstone once more becomes yellowish and argillaceous, and is surmounted by the red and greenish shales of F. XI., with which these upper beds alternate. In these alternations lies an important bed of *iron ore*, to which I shall presently recur.

Red and greenish shales and argillaceous sandstones of the same colors, occupy the vallies of F. XII. already mentioned. Among the lower layers of the formation, we encounter an interesting band of limestone, found in Trough creek, Plank Cabin, and several of the other red shale vallies. This is probably the equivalent of the limestone, which occupies a corresponding position in F. XI., in the Allegheny mountain and other ridges bordering the bituminous coal basins of Somerset and Cambria counties, and which extend thence into Maryland and Virginia.

Formations XII. and XIII. will be described when treating of the geology of Broad Top mountain.

Physical features of the Region.

Commencing with the knob of Terrace mountain, which terminates the synclinal valley, in a remarkably symetrical mountain, jutting boldly forward to the margin of the Juniata, the encircling belt of mountains here divides, and forms on the north-west Terrace mountain proper, and on the south-east Sideling hill enclosing an elevated basin-formed valley of the red shale, sloping with remarkable regularity from this extremity toward the base of Broad Top. Sideling hill running east of Chilcoatstown, bounds Well's valley on the east, while Wray's hill rising at De Forest's, three miles from Chilcoatstown, bounds the same valley on the west. After extending south some miles, this latter ridge curves rapidly backwards for some distance, when it again resumes its south-west direction, until it unites with Broad Top, to enclose the coal region. Opposite the curve, Harbour mountain commences, consisting of the sandstone F. V., elevated by an anticlinal axis. It separates Well's valley from another valley of the red shale F. XI., lying west of it, known as Ground Hog valley. Harbour mountain, dividing into two ridges, the eastern one curves eastward and unites with Sideling hill, thus shutting in Well's valley; the western one bending elliptically round the coal region to join Terrace mountain. This last named ridge ranges about south-west; tracing it along Trough creek valley, its south-east side slopes less and less until within eight miles of Savage's furnace, where the ascent from the valley to the summit is not more than five or seven de-

grees. There is a remarkable projection in the mountain on the south-west side of Norris's notch: that section of the ridge being heaved to the west. Something of the same feature is perceptible at Trough creek gap, to which points the axes disturbing the coal basin, are distinctly traceable. The mountain from Trough creek gap to its junction at Harbour or Cross mountain, is extremely regular. The interval between the two ridges, is occupied by Broad Top mountain and its coal basin, the topographical features of which we shall now briefly sketch. In order to do this intelligibly, we must trace the position of its axes of elevation.

BROAD TOP MOUNTAIN.—*F. XII., and Coal Measures.*

The north-east extremity of the coal basin terminates in a series of spurs, formed by several anticlinal and synclinal axes. The portion of the coal field lying towards the south-west, not having been yet explored by us, we cannot trace with precision the prolongation of these axes, in that direction. Broad Top mountain throws out no less than four spurs into Plank Cabin and Trough creek vallies. The first, and most eastern of these, is *Shirley's knob*, or its continuation: the second is *Round knob*, one of the highest: the third is called *Broad Top*: and the fourth lying nearest Terrace mountain, has no distinctive name, but Broad Top. Another knob called Round Top, rising directly at the furnace, is situated apparently in a line between the last mentioned spurs. Shirley's knob, and its continuation, is of synclinal structure, and this axis prolonged north-eastward, is the axis of Trough creek valley. South-westward it passes through the centre of Rocky ridge, which is composed of two ridges, or at all events, may be described as having two summits, between which lies Savage's coal seam, the lowest bed in the series. After passing through Rocky ridge, which, properly speaking, terminates two or three miles south-west of Savage's coal mine, in a high conspicuous knob; this trough, or synclinal axis, crosses the little valley of F. XI., near Mr. Samuel M'Lenn's, and enters the knob *there* known as Broad Top, beyond which we have not pursued it. The next spur or knob, called Round knob, from its nearly circular, level summit, constitutes the second lesser basin, formed by the synclinal axis, which, leaving it, enters another knob opposite to it, called Grave mountain, from whence it ranges through the coal region. The anticlinal axis interposed between these two synclinal ones, passes between Rocky ridge and Round knob, crosses the little valley near M'Lean's, and extends thence between Broad Top and Grave mountains, while in the opposite direction, it can scarcely be traced to Trough creek.

The third spur, otherwise called Broad Top, contains the third synclinal axis, giving it therefore a basin-like structure. The second anticlinial axis, included between this last and Round knob, elevates F. XI. in Plank Cabin valley. The next spur towards the west, contains the fourth synclinal axis, which either enters Round Top at the furnace, or passes to the west of it, leaving it as a hill of elevation,

thrown up by the third anticlinal axis, prolonged from between the third and fourth spurs. Most of these axes expire at Trough creek, thus spreading, in nearly horizontal position, the sandstone F. X. over a wide tract at the upper end of the valley, denominated the *Barrens*. Trough creek forms a natural boundary between this sandstone and the overlying red shale F. XI. Besides the axes already mentioned, there is a synclinal axis in Wray's hill, and an anticlinal axis between this and Rocky ridge. Wray's hill may be considered, geologically, as commencing at De Forest's, three miles south-west of Chilcoatstown, though it is continued by short and low knobs along the east flank of Rocky ridge and Shirley's knob. Further to the southwest, it acquires two summits under the title of Rocky ridge. The western ore widens beyond the end of Rocky ridge, and contains not only the synclinal axis, but an anticlinal one. Whether this latter traverses Wray's hill into the Harbour mountain is, at present, uncertain. Thus, at the north-east end of the coal region, we have in all, five basins in the strata, and four interposed anticlinal axes; an accurate knowledge of the position of which becomes of the utmost practical importance to develope the coal seams of this richly supplied region. These axes of elevation give to the surface of the general coal field of Broad Top an undulating outline, which has been rendered more irregular by the operation of great floods, cutting the flanks of this elevated table land into numerous deep ravines. The tangled thickets of laurel with which these are filled, and the fewness of good exposures of the strata, render the accurate exploration of this region a work of time and patience, and the late period of the season at which it was entered on, prevented our completing its investigation. Towards its south-west end, the structure of the region becomes somewhat easier to recognize, the exposures of the rocks furnishing more ample data. Another season, it is believed, will place us in possession of full information respecting the number, relative position, and range of the several coal seams and beds of iron ore, some details respecting which, I shall presently return to.

Directing our attention first to the resources of the surrounding red shale vallies, let us allude to the limestone and iron ore which belong to the bottom of F. XI.

Limestone.

A bed of greyish or clouded white limestone, occurs near the alternation of F. XI., and the subjacent sandstone. This rock is somewhat siliceous, and probably quite magnesian, burning with difficulty into lime. It is also slightly fœtid, and breaks, by exposure, into conchoidal fragments. In some localities it is purer, and has a smoother grain. This band of greyish limestone is from two to three feet thick. It has been opened on Little Trough creek, where it is nearly horizontal. Above this bed, lies a reddish limestone, about the same thickness, supporting a red shale, which is decidedly calcareous. These red and grey limestones are evidently equivalent to

those which occupy a similar position in the series, west of the Alleghany mountain. A variety, having a finer grain, is found on Mr. Adam Lovel's farm. Here the rock is smooth, and has a cherty lustre; it makes a dark lime. The belt continues north, along the edge of the Barrens, through several farms; the layers being well exposed. Another belt should extend along the base of Sideling Hill, where hitherto it has not been sought for; the limestone following Little Trough creek to its junction with Big Trough creek, ranges near to this stream through Plank Cabin valley. A short distance from the furnace it is again quarried, is about three feet thick, and overlaid by calcareous red shale; it has been employed as a flux in the Trough Creek furnace. This belt should range through Little valley, between Terrace Mountain and Broad Top, near the base of the former. It is exposed on the road to Stonestown; it is visible at several points in Well's valley.

Iron Ore.

There is a massive variety of iron ore, which has been opened to some extent, near the Trough Creek furnace, and also in the vicinity of Hopewell furnace; it occupies a position at the very base of the red shale, at its contact with the underlying sandstone of F. X. Occurring in the gently inclined plane at the base of the mountain, this seam of ore might be naturally supposed to result from the percolation of water through the ferruginous sandstone of the mountain, but we hesitate in adopting this conclusion, when we reflect on the position of the ore at Hopewell furnace, where it appears to exist as a regularly interstratified bed between the rocks, much in the same manner as we find the fossiliferous ore in F. V. The excavations attached to Trough Creek furnace, are situated at the base of Terrace mountain, about one mile from the forge. The ore lies in lumps closely bedded together, suggesting, by the regularity of their position, and by the absence of much interposed earth, that they belong to the outcrop of a continuous bed. It exists in about five different varieties, several of which are very compact forms of the ordinary brown iron ore. When smelted by itself, it is stated to produce a highly coldshort metal. The analyses to be found in chapter VI., will exhibit its chemical nature.

The same ore is opened near *Hopewell furnace*, on both sides of the gap in Terrace mountain. The excavations on the north-east, are open to the day, but on the south-west side of the gap, the ore has been reached by a regular tunnel, ninety yards in length, intercepting the vein ninety feet below its outcrop, on the slope on the mountain. An air shaft extending up the vein, from the tunnel to the surface, exposes it, varying in thickness from twenty inches to three feet. Galleries or drifts have been made in both directions from the tunnel, but the seam of ore diminishes in thickness, and threatens to thin out. A shaft has been subsequently sunk, reaching the vein at a point forty feet below the level of the tunnel, where it retains the same

thickness as above. It lies immediately at the contact of the sandstone with F. XI. It is interstratified with more or less clay. The ore here is of three kinds, the most abundant being brown, brittle, and of a smooth jaspery fracture, resembling closely one of the varieties at Trough creek. This species is said to make good iron, and to yield fifty per cent., which certainly seems to be a large amount. The second variety is of a more yellow aspect and slaty structure. The ore in the open diggings, on the opposite side of the gap, occurs also between the sandstone and red shale. The contour of the hill side, at this place, is such as not to imply an origin from infiltration; the ore appearing rather to be the outcrop of a regular vein. The adjoining red shale occurs in thick layers, which are soft and friable, and sometimes of a bright red hue, immediately contiguous to the ore. Near the margin of the deposite, thin layers of a sandy ore are interstratified with the red siliceous shale or sandstone, and approaching the vein, the red shale is disintegrated, passing to a sandy clay. Towards the middle of the deposite, the ore is both sandy and argillaceous. The principal mine is about 100 yards in length, and open to the day. The coarse yellowish white sandstone, F. X., forms one side of the deposite from which the ore has been removed. This bright red clay included among the ore, answers as a substitute for paint.

Iron Ore between F. XI. and F. XII.

In the alternating beds at the junction of F. XI. and F. XII., we meet with fragments of ore of a light chesnut brown color, similar to one of the varieties found in F. V. It would seem to be neither rich nor abundant. This ore is visible at the north-east end of Wray's hill, which is composed of these alternating rocks; and it occurs also in several other positions, easily traced by attending to the stratification, and the range of the axes previously mentioned.

Broad Top Coal Region.

The sandstone, F. XII., which immediately underlies the coal measures of Broad Top, possesses little of the conglomerate character which distinguishes it where it borders most of the other coal fields of the State, both in the anthracite and bituminous regions. It is hence not readily distinguished, in all cases, from some of the sandstones included between the coal, though a careful observer will find but little difficulty. The overlying coal measures appear not to be extensively developed, until we reach the central and south-western portions of the basin. After devoting a general, but tolerably minute examination, to be renewed hereafter, to the several spurs projecting into Plank Cabin valley, we have reached the conclusion that none of these synclinal axes, but Rocky ridge, contains any coal. The seam in Rocky ridge terminates about one-fourth of a mile south-west of the gap at Trough creek, the sandstones of F. XII. occupying, after-

wards, the whole summit. It does not apparently prolong itself into Shirley's knob, the peculiar form of which seems to preclude its existence there. The sandstone, F. XII., occupies this hill from the creek to the summit of the knob. We shall allude in another place to the range of the coal seam through Rocky ridge. As the red shale, F. XI., extends far up the flank of Round knob, there is but little possibility of a coal seam in this spur; and the occurrence of the same stratum, nearly on the summit of the Grave mountain, in the same bearing as Round knob, is a further corroboration of this opinion. For a similar reason, the existence of a coal seam in either of the other two spurs of Broad Top, which extends into Plank Cabin valley, is somewhat doubtful; but this point will be definitely settled during the coming season. On Round Top, near the furnace, no bed of workable coal, we conceive, can occur. The alternating beds at the passage of F. XI. into F. XII., may be observed in a knoll on Trough creek, opposite to De Forest's, which is a continuation of Wray's hill. These consist of yellowish and greenish sandstones, red shales, and again of layers of a fine grained, very argillaceous green sandstone, making admirable whetstones; these beds indeed furnish whetstones in many places surrounding the coal region. Underlying the coal seam at Savage's mine, there is a stratum prominently exposed on the west side of the ridge, of a hard and massive, but fine grained white sandstone, speckled with mica. The angular fragments of this rock enable us easily to trace it through Rocky ridge. It is again seen a mile and a-half south of Savage's mine, on the eastern ridge, supported by a brownish grey sandstone. Below the latter are massive beds of a white sandstone, composed of granular milky quartz. Pursuing F. XII. along Rocky ridge, the upper sandstone maintains its character, while the lower bed becomes coarse—containing grained white quartz pebbels of the size of a grain of pepper, showing thus an approximation to the conglomerate type of the formation.

Where Trough creek rushes between Rocky ridge and Wray's hill, two and a-half miles south-west of De Forest's, is a high escarpment of sandstone, called the *Raven Rock*. The best exposed strata here underlie all of those above described, and consist of grey, whitish, and brownish hard sandstones, generally coarse grained, including occasionally thin layers of black carbonaceous shale containing vegetable impressions.

The Coal Seam in Rocky Ridge, has been opened adjacent to the western summit, about three-fourths of a mile S. W. of the gap occupied by Trough Creek. The coal dips at the mine sometimes towards the south, though more frequently south twenty-five degrees east, at an average angle of twelve or fourteen degrees. It is about four feet thick, is of excellent quality, and convertible into a good coke. Numerous oblique transverse joints divide it into rhomboidal fragments. The seam is overlaid, and also supported by solid layers of dark fine clay, each about six inches thick, which by exposure are converted into a plastic clay.

guide in determining the number and relative position of the coal seams of the basin.

Coal has been opened on the farm of Mr. James Tigard, a mile and a-half from the hill. It dips south, and is said to be two and a-half feet thick. About two miles from the mill, another excavation on the land of Messrs. Lloyd and Patterson, occurs in coal said to be five feet thick, dipping to the south; and another is to be seen at Mr. Richard Foster's, three and a-fourth miles from the mill, where the bed is two feet thick.

Near Trout run, about three and a-half miles from Hopewell furnace, occurs a valuable seam of coal, dipping seven degrees to the W. N. W. but becoming more inclined as we recede from the outcrop. In the main drift of the mine this bed is upwards of five feet thick and increases to seven and even eight feet. The overlying slate is hard and heavy and like that of the bed at the Riddle mine. The two coals also resemble each other, and belong probably to one seam, though they occupy different positions with regard to the axis of elevation. Like nearly every other bed of bituminous coal, it contains thin laminæ of slate, and a little sulphuret of iron. Between the above large vein and Hopewell furnace there is another, appearing about a mile and a-quarter further west, which is eighteen inches thick. This is probably that which overlies the Riddle bed, and if so, the principal seam should be found at a lower level in the small ravine of the mountain. One point is clear, that the seam at present worked for the supply of Hopewell furnace, should crop out at least in three different places nearer the furnace than where the mines are now established. This information was imparted to the manager of the furnace.

Section V.

District between Tussey's mountain and the Allegheny mountain.

The next belt of country embraced in the investigations of the past year, in the portion of the State before us, comprehends the interesting chain of vallies lying between Tussey's mountain and the base of the Allegheny. The exploration commenced in the neighborhood of Pine Grove, west of the termination of Stone valley, and extended to the southern end of Morrison's cove, the close of the season arresting our further progress. The north-eastern extension of this belt through Centre county, was examined in much detail during the previous summer.

Commencing our present brief account of the formations, with a sketch of Tussey's mountain, we shall trace this ridge from Pinegrove to the Raystown branch. Between Pinegrove and the Little Juniata river, the structure of the mountain is rather uniform. The white sandstone, the upper of the three divisions of F. IV., forms a nearly straight, occasionally undulating summit, in which the depressions are few and not deep. A terrace or bench occupies its north-west slope, a considerable distance below this crest, intersected as usual, at intervals averaging about three-fourths of a mile, by deep ravines, or short vallies of denudation. In some places, the terrace nearly rivals the principal summit in height. Approaching the river it becomes more depressed, the ravines more numerous, and the northern slope of the mountain more abrupt. Still nearer the Juniata, the proofs of violent denudation by water are still more striking, the margin of the terrace appearing sometimes as a bold escapement of the lower grey sandstone of F. IV. That section of the ridge, included between the Little Juniata and the main river, called Short mountain, present a regular summit; but the denudation has been such as to leave scarcely any terrace. From the Frankstown branch south-west for a few miles, the mountain does not reach its usual elevation. The river here has its course in the soft red argillaceous rocks, composing the middle division of the formation, leaving the lower sandstone in a small, sharp, isolated ridge of the shape of a colossal grave. This is about two miles long, the river intersecting the lower sandstone by a gap above which it flows in the slate F. III., and the limestone F. II. of Canoe valley.

About five miles from Alexandria, the whole mountain exhibits a remarkable displacement in its course, forming a flexure like the letter S, caused by the folding round of the formation over a short anticlined axis, which runs obliquely from the main axis of elevation of the valley. South-west of this curve it pursues a regular course, with some trivial inequalities, to Yellow Creek, ranging about south thirty degrees west, while its direction north-east of the Little Juniata, is about south seventy degrees west. Approaching Yellow Creek, there are several unimportant notches in the main summit of the ridge, but no true gap exists until we advance within a few miles of another double flexure of the mountain near Yellow Creek. North-east of this stream occurs a flexure similiar to the former, produced by the termination of an anticlinal axis deflecting the mountain for a space out of its regular course. This axis of elevation is continuous with that which produces a corresponding flexure in the Muncy mountain, enclosing Brush Valley. From the neighborhood of Yellow Creek, the mountain becomes higher, more regular, and exhibits less waste from violent floods, the terrace rising to a great elevation.

At the gap of Yellow Creek, the strata dip forty degrees to south seventy-five degrees east. From this point to the gap at Raystown Branch, the formation is uninterrupted, presenting merely a slight deviation in its course near the termination of Morrison's Cove, curving

a little more towards the meridian, where it forms the east side of Snake Spring Valley.

The slate F. III. ranging at the base of Tussey's mountain, skirts the eastern side of the Great Limestone Valley, throughout its entire length, maintaining great uniformity in its aspect and structure. At the contact of this rock with the overlying sandstone of F. IV., we perceive layers of black and dusky olive slate, alternating with dark argillaceous sandstones. Approaching its inferior limit, the slate begins to alternate with dark argillaceous limestones; these calcareous bands, increasing in number and thickness as those of the slate, progressively diminish.

Along no portion of the belt does the slate appear as a very thick stratum, its maximum depth probably not exceeding six hundred feet. It generally composes the lowest part of the aclivity of the mountain, sometimes extending nearly to the verge of the terrace on its side when the denuding action has been relatively feeble. At Lower Colerain Forge, near the Little Juniata, it gives proof of considerable waste by floods, Spruce Creek having its channel in this slate, sweeping the foot of the terrace, while the dark grey sandstone, the lower division of F. IV. rises from the stream in a tall escarpment or wall. At the folding round of Tussey's mountain opposite Williamsburg, the slate is embraced in the recess, forming two short hills jutting forward at right angles from the main ridge.

Limestone F. II.

The anticlinal axis of Brush valley, elevating to the surface, the limestone F. II., near the head of that remarkable nook, terminates in Morrison's Cove, south-west of Martinsburg.

The country between Tussey's mountain and the first range of barrens, traversing the central part of the main limestone valley, north-east of the Juniata, is a gently undulating surface, along which the limestone is elevated by an anticlinal axis, prolonged from Penn's Valley. The banks of Spruce creek, exhibit occasionally fine exposures of the strata, forming the south-east side of this axis, while Warrior Mark run intersects it diagonally. The little Juniata itself exhibits a section of this part of the belt, showing satisfactorily the true position of the axis. The rocks on the south-east side of the line of elevation, dip to the south-east at an angle of about forty degrees, while the inclination of those on the opposite side, to the north-west, is somewhat steeper. A section a few miles further to the south-west, displays a change in the position of the strata. Crossing their outcrop from the end of Cove mountain to Tussey's mountain, the rocks on the north-west side of the axis are nearly vertical, while those south-east of it, though sometimes steep, have generally a less inclination. The line of elevation in the limestone, takes here a course more towards the south. The belt of the valley between the two mountains is elevated, and the slate spreads to a considerable distance from the base of canoe Mountain. The valley sometimes called Canoe valley,

is traversed south-westward by the axis, preserving the same nearly vertical attitude, in the strata along its north-west side. The Juniata river, after crossing the valley at Williamsburg, winds along the south-east side of this axis, sweeping sometimes the base of the mountain in the slate of F. III., sometimes cutting through the limestone almost to its line of elevation. The only interruption which this anticlinal line presents, is when it sends off the short axis of elevation, which causes the flexture in the mountain south-east of Williamsburg. Beyond this point, to the other similar bend in the mountain, at Yellow creek, opposite which the axis terminates, it is remarkably regular. This axis, which we have been tracing, terminates in the little sharp cove, south-west of Martinsburg.

In the wide limestone valley, embraced between Tussey's mountain and the Bald Eagle or Muncy mountain, we have two parallel anticlinal axes; that on the south-east being the same which elevates the rocks in Brush and Penn's valleys, and that on the north-west, the prolongation of the axis of Nittany valley, the included trough or synclinal axis, being the same which contains the Nittany mountain. About ten miles south-west from Bellefonte, the Nittany valley axis loses its symetrical structure; the strata lying north-west of it becoming vertical, and soon afterwards *inverted*, ranging in this attitude through Halfmoon and Warrior Mark vallies, into Sinking valley, five miles south-west of the Little Juniata. Here the rocks resume their more natural posture, dipping to the north-west until the axis terminates south of Hollidaysburg.

The trough or synclinal axis of Nittany and Canoe mountains, is occupied by an extensive range of sandy barrens, which stretches almost uninterruptedly from the bed of the one mountain, to the commencement of the other. Along this line there are few exposures of the strata. In this belt occur the chief deposites of brown *iron ore*, for which this valley is remarkable. There would appear to be, however, no strict rule of uniformity as respects their position. A fertile tract, in which the limestone shows itself, borders this range of barrens on both sides, extending to the foot of the bounding mountains. That on the north west forms the vallies of Half Moon and Warrior Mark, while Spruce Creek valley forms the belt on the south-east. The barrens themselves consist of broken and undulating hills, separating in some places into two ranges, corresponding to the two anticlinal axes of the district, enclosing numerous hills of sand and clay, between which we occasionally meet with exposures of the lower beds of the limestone. These intervening lower hills present no uniformity. In some places the barrens embrace four ranges of hills, and in some places three. The relation of these hills to the enormous deposits of iron ore near them and among them, is as varied as their topography, though something like system is observable; thus on the north-west side of the broad synclinal axis, there is a long chain of ore banks, extending from near Bellefonte to the Little Juniata, not departing far from the line of the Nittany valley axis. The ore beds lie usually on the range of sandy hills, on their south-eastern slopes, and near their

summits, though sometimes they occur on their very tops, and again on their sides facing the north-west. The hollows between these hills also contain, occasionally, rich accumulations. These are the positions of the large ore banks of Julian, Curtin's, Hannah, Bald Eagle and Huntingdon furnaces. The south-eastern anticlinal axis presents us with but one group of ore banks, namely: those attached to Pennsylvania furnace, but there are a number of other excavations in the intermediate space between the two ranges.

All the ore of this belt of country belongs to one general species, the brown or *hematitic iron* of mineralogists; it exhibits, however, an almost endless variety of structure and much diversity of composition. Some of it is earthy and compact, approaching the jaspery iron ore; some of it highly porous and cellular; some regularly stalactitic, receiving the name of *pipe ore*, while other portions occur in hollow geodes, often lined with the crystalline hematite, and occasionally filled with water. The imbedding earth is itself no less various, consisting of clays and sand of nearly every hue: brown, yellow, red and other tints, derived from the oxide of iron. The lumps of ore are lodged in these deposites in almost every conceivable manner; sometimes in isolated pieces in the clays, sometimes, in narrow layers called veins, sometimes grouped into bunches, and sometimes forming vast blocks, weighing each several tons. The chemical composition of these ores, will be specially alluded to in the final chapter of the present report, where mention will be made of our iron ores generally.

The only indication to be relied upon in seeking for the ore, is the relative abundance of its fragments upon the surface.

The Slates of F, III.

The slate ranging along the north-west side of this belt of limestone vallies displays the same features already noticed, as characterising it at the foot of Tussey's mountain.

The Sandstone Rocks of F. IV.

These form Bald Eagle, Brush, Canoe, Lock, and Dunning mountains bounding this chain of limestone vallies on the north-west and west. At Milesburg, in Centre county, the strata dip steeply to the north west, their angle being nearly seventy five degrees. From this point south-west for some miles, the crest of Bald Eagle mountain, is high and undulating, its south-east flank containing the usual terrace. About eight miles from Bellefonte, its features change in conformity with the abrupt overturn of the rocks near the anticlinal axis. The crest and terrace of the mountain become depressed, and more irregular in their outline. The Slate F. III., rising to the verge of the terrace, and sometimes even forming a part of it, while this shelf is more frequently cut by deep ravines. These are quite conspicuous near Hannah and Bald Eagle furnaces. The Little Juniata river affords a

good display of the rocks of F. IV, in this mountain, which ranges with little deviation to a point about five miles south-west of the river. It then undergoes a remarkable alteration in its outline, the crest rising suddenly to a conspicuous height above the low, denuded terrace. A corresponding change in the attitude of the strata, explains this new feature. The rocks north-west of the axis, which for a previous distance of several miles, are inverted or overturned in their dip, here assume a less disturbed position, inclining regularly to the north-west, the massive sandstones of the mountain involved in the same derangement, assuming also their natural attitude. Throughout that part of their course, where they stand nearly vertical, or have been crushed more or less by the invertion, they have opposed a less resisting barrier to the tremendous energy of the denuding waters, which have shaped the vallies and mountain ridges of our State. Where the rocks change their posture and take a gentler dip, they presented a broader bulwark to the floods, and have, therefore, undergone a less extensive devastation. From this point to Hollidaysburg, where the great sandstone formation folds over the expiring axis of Nittany valley, the mountain preserves great uniformity of structure, its crest being high and regular, and the terrace broken as usual at given intervals by deep ravines. A slight change in the direction of the mountain, occurs a short distance north of Black's gap, opposite to which the main limestone valley terminates in a little trough shaped one, about two miles in length, produced by the scoping out by the waters escaping through this notch, of the soft middle strata of F. IV., the denundation of which usually causes only a flat shelf or terrace.

The sandstone belt F. IV., sweeping round the end of the axis in a broad knob, north of Hollidaysburg, assumes a north-east direction to form the north-west boundary of Scotch valley. At the head of this, falling into the synclinal trough, prolonged from Nittany valley, it curves suddenly back to the south-west, making the end of Canoe mountain, where it displays a prominent synclinal knob, flanked on each side like those in Kishicoquillas valley, by a broad terrace of the middle beds of the formation. From this end of Canoe mountain, the formation ranges in a regular ridge for about five miles. The Slate F. III., occupying every where its usual position at the base of the ridge. Opposite Etna furnace, the mountain exhibits a sudden and remarkable change in its strata, which are heaved by a dislocation, much to the west of their previous range, and at the same time inverted, presenting a broad irregular bulge at the commencement of the overturn. This fracture in the rocks gives rise to a very complicated structure from this point to the gap at the Juniata, a description of which could not be rendered intelligible without the aid of a map and sections. Short mountain or Canoe hill, is the regular prolongation of Lock mountain, separated from it only by the gorge at the river. From this point to the end of Lock mountain, where it folds under the synclinal axis, north of Martinsburg, the formation is regular, dipping steeply to the north-west, the upper division forming the high sharp crest of the ridge and the lower, the margin of a well defined terrace.

Curving as it passes the synclinal axis, the whole formation folds back towards the north-east, to double once more towards the south in the broad and high knob, south of Frankstown, where it folds over the anticlinal axis, which ranges from this point through Brush valley, as already described. From this point, it pursues a nearly southern course, under the name of Dunning's mountain, showing conspicuously the effects of denuding action, until it curves again at the head of the valley called Dutch Corner. The low and broken double crest of the mountain throughout this part of its range, is the result of a vertical upheaving of the rocks, and their consequent shattered condition, by which, as in the instance of the Bald Eagle mountain, the strata have been more readily affected by denuding currents than elsewhere. At the curve of the mountain at Dutch Corner, its features change; instead of presenting a double chain of knobs, one formed by the upper, the other by the lower, sandstone belts of the formation, the whole stratum doubles over a short anticlinal axis, which diverges from the centre of the valley, imparting greater height and regularity to the summit. After making a double flexure round this axis, and round the head of the synclinal basin in Dutch Corner, the mountain resumes once more a S. S. W. direction. At the most eastern part of the bend, the lower strata of the formation coalesce with the corresponding ones in Tussey's mountain opposite, thus closing up the lower end of Morrison's Cove, leaving only a narrow rugged passage between it and the next, or Snake Spring valley on the south. The mountains soon separate, the same anticlinal axis elevating the limestone in the southern part of Morrison's Cove, and lifting this rock to the surface in the adjoining valley just mentioned.

From the end of Lock mountain to the synclinal axis S. E. of Woodbury, which is a prolongation of that passing through the knob of Lock mountain, Morrison's Cove embraces two lines of elevation, and one of depression, in the strata. The axis of Snake Spring Valley, commences at Frankstown, and passing through the knob just south of it and through Brush valley, traverses the Cove, and enters Snake Spring Valley by the pass above described. The rocks on the east of this line dip east twenty-five degrees, while those on the west dip forty-five degrees to the west, and are in some places vertical.

Iron Ores.—Near the line of this axis we have a belt of barrens, composed of superficial sand and clay with iron ore, similar to that noticed in the same limestone range further to the north-east. The denudation in Morrison's Cove, having been less than in the other part of the belt, the deposites of clay and sand occupy a wider zone along its centre. Connected with Sarah and Woodbury furnaces, there are many extensive excavations for iron ore; but want of space will not permit me to describe these and the other interesting mines of this belt in detail, or do more than present a brief sketch, together with some analyses of the characteristic varieties of the ore. The ore belongs to the brown hematitic species, common in the limestone vallies, its two predominant varieties being the compact brown ore, either in large masses, or minute fragments, and a massive cellular ore of a

somewhat lighter tint. Another belt of ore deposites, occupying the other anticlinal axis of the cove, presents a greater diversity of forms.

Springfield furnace has around it several ore banks which furnish a great variety: one yielding a large supply of rich ore mingled with much sulphuret of iron; another affording a dark variety, in great abundance, containing much oxide of manganese, while another bank supplies a hard and siliceous lump ore. But besides these kinds there is an immense quantity of ore of superior quality.

The ore banks of Rebecca furnace, produce also, many sorts. One furnishing in part *pipe-ore* of the richest kind; another a compact hematite in large lumps and hollow nodules of every size and form; and another, an ore so sulphurous as to be unfit for the furnace. The analyses in chapter VII., will exhibit the usual composition of the better kinds of ore found so abundantly along this central belt in Morrison's Cove.

Snake Spring Valley, is but the northern termination of a long and rather regular valley of elevation, which south of the Raystown Branch of the Juniata, takes the name of Friend's Cove. It consists centrally, of the limestone F. II. bounded on each side by the overlying slate, ranging at the foot of Tussey's mountain on the east, and Dunning's or Evitt's mountain on the west. From the head of Snake Spring Valley, it is traversed by an anticlinal axis, on the western side of which, the limestone is sometimes nearly vertical, and is every where steeper than on the eastern. This cove or valley, has not yet been explored in detail.

Of the Valley at the base of the Allegheny Mountain.

Red and Variegated Shales, F. V.

The north-west flank of Bald Eagle mountain being generally covered throughout its lower half by a deep deposite of debris, washed from the adjoining ridges, the shales of F. V. are visible in but few exposures from Milesburg, to the Juniata river. This formation has been penetrated at a number of points in pursuit of the fossiliferous iron ore which belongs to its middle strata, and though some of the calcareous layers have been found slightly impregnated with oxide of iron, the true fossiliferous ore has not been yet discovered. Several openings have been made at Julian and Hannah Furnaces. Here the shales occupy the slope of the mountain, and where the dip is vertical, extend sometimes to its summit. The lower, more gentle acclivity of the mountain, formed by the soft shale, is usually covered with oak; the higher and steeper slope caused by the sandstone F. IV. sustains more generally pines. This order of things prevails to the point where the vertical attitude of the rocks passes into a more gentle dip, accompanied by an increased altitude of the ridge, beginning about five miles north-east of Tyrone Gap. From this point the fossiliferous ore [illegible] sual position in the stratum on the north- [illegible] t a short distance from its base, its out-

crop being designated by a slight elevation. The ore varies from ten to sixteen inches in thickness. It is compact and moderately rich, and is associated with calcareous beds containing but little oxide of iron. Both the ore and the calcareous layers, are interstratified with beds of olive-colored slate, unaccompanied by any stratum of sandstone either above or below them, such as designates the ore in the Lewistown and Stone Vallies. Near Bell's furnace, the ore has been opened in several places. When mixed with the compact brown ores from the limestone belt on the south-east, a very superior iron is abundantly produced.

Formation V., attended by its belt of fossiliferous ore, maintains the same position near the foot of the mountain, until the rocks fold over the articlinal axis at Hollidaysburg. Here the inclination of the bed is very gentle. Hollidaysburg stands upon the feruginous layers, in the upper part of F. V., further south from the knob of the mountain than the outcrop of the genuine seam of ore. Near Frankstown, the fossiliferous ore is met with among the olive shades of F. V. associated with a few thin calcareous and ferrugiuous layers, and unaccompanied by any bed of sandstone of sensible thickness. The layer of ore at this place is fourteen inches thick, and near its outcrop is of very superior quality, containing but little calcareous matter. It is smelted in the Frankstown furnace by itself and affords a large proportion of iron. The mine is on the south slope of the mountain, and one mile north-east of of Frankstown.

Several exposures of a thin impure fossiliferous ore are visible in the town of Hollidaysburg; but these occur too high in the formation to be a part of the true ore bed. This ferruginous calcareous seam is associated, moreover, with a different group of rocks from those which imbed the true fossiliferous ore, as we may plainly behold, in a fine section of the strata on the Portage railroad, three-fourths of a mile above the town. At this place we witness a number of the same feruginous calcareous seams, from one to eight inches thick, interstratified with variously colored shales, sometimes several feet in thickness, and with still thicker beds of sandstone. Some of this fossiliferous material is moderately rich in iron, while other portions are hard and superabound in calcareous matter. After doubling over the anticlinal axis at Hollidaysburg, the ore bearing formation F. V., takes its course along the base of Brush Mountain, bordering Scotch Valley on the north-west. We have here the same condition of things as upon the north side of the axis, F. V. forming the base and lower slope of the mountain, and a low protuberance on the flank, marking the range of the fossiliferous ore. It is exposed in a number of places, though hitherto it has not been extensively opened.

The shales of F. V., folding round the end of Scotch Valley, here called the Beaver Dams, assume a south-west direction along Canoe mountain, ranging regularly as far as the dislocation north of Williamsburg, where the stratum becomes involved in the sudden invertion which affects all the rocks of the mountain, becoming concealed until the ridge terminates at the river, where the beds appear in the

most contorted and disturbed position. Here a number of excavations have been made in quest of the fossiliferous ore, but the strata are so confused and crushed that it is not traceable for any distance, appearing to divide in some cases into several thin calcareous seams, slightly impregnated with iron. It is barely possible, however, that these represent not the true fossiliferous ore, but the ferruginous and calcareous layers found at Hollidaysburg. On the the north side of Canoe hill, the shales assuming their regular position, or a steep north-west inclination, the ore exists in a thin bed of porous structure, between six and eight inches thick, unaccompanied by any thick layer of sandstone. It has been opened for the adjoining furnace, but will not repay the cost of mining it.

The formation resting steeply on the flank of Lock mountain, rises high up on its north-west acclivity, and is thickly covered by fallen earth and fragments from the ridge. Ranging to the south-west, it curves round the loop or recess of Old Town run, following the recurving spur of the ridge with a gentle south-east dip. In this part of its course, the fossiliferous ore is embraced in the hills at the base of the mountain, being discoverable on the surface in numerous rich specimens. The bed itself was found exposed two and a-half miles from the head of the loop. The ore is good, though only seven inches thick. A thicker seam may exist, but such was not discovered. The ore bearing formation folds over the anticlinal axis in the Broad Knob, south of Frankstown, to follow Dunning's mountain, towards the south. This ridge having its strata vertical throughout a course of many miles, the shales, F. V., rise in this case as they usually do, high up upon its slope. At the gap, near Martha forge, they form a constituent part of the mountain, the limestone F. VI. and sandstone F. VII. lying at its base. As far south-west as Sarah furnace, the fossiliferous ore does not show itself on the surface, in consequence of this state of things, the only exposures of the strata being in M'Kee's gap at Martha forge. At this place, some of the upper shales adjacent to the limestone, are visible, but the fossiliferous ore cannot be detected by any indications on the surface, the portion of the stratum containing it being too much concealed.

Limestone F. VI., and Sandstone F. VII.

Ranging near the base of the Bald Eagle or Muncy mountain, and the ridges forming their continuation towards the south, the fossiliferous limestone and overlying sandstone usually form a more or less distinct ridge, which is sometimes, however, obliterated by denudation. The average thickness of the limestone is probably about two hundred feet, while the coarse sandstone that surmounts it, is usually not more than one-fourth of this thickness. From Milesburg to the Little Juniata, in consequence of the nearly vertical attitude of the strata, both of these formations are very obscurely exposed. They rest close under the base of the mountain, while the dark slates of F. VII. generally occupy the valley between them and the Allegheny

mountain. At Julian furnace they do not appear on the surface; but from information imparted to the proprietor, respecting the position of the limestone, it has since been reached, thus saving him the necessity of procuring a flux from the other side of the mountain.—A range of *sink holes* at the base of the ridge generally indicates the position of this limestone. It forms, however, a short ridge at the foot of the mountain, a few miles south-west of Bald Eagle furnace, continuing, with occasional interruptions, nearly to M'Cammit's forge. A few massive beds of the overlying sandstone occupy the north-west slope of this ridge, beyond which, to the north west, commence the slate of hills of F. VIII. Where the river cuts the ridge, one mile south-west of Crotzer's forge, the whole thickness of the sandstone stratum is between sixty and seventy feet.

There is a change in the attitude of these two formations, corresponding to the altered posture of all the rocks, commencing at the rise in Brush mountain, five miles south-west of Tyrone gap, their previous steep inclination to the north-west, giving place to a gentle dip, succeeded further to the south-west by an anticlinal axis, occurring at some distance from the base of the mountain. The trough in the strata, between the mountain and this anticlinal axis, embraces a synclinal ridge of the sandstone F. VII., supporting the lower dark slates of F. VII., in the vicinity of Bell's ore bank. This synclinal axis, analagous in all respects to those previously described, as traversing the Lewistown valley, contains the valuable ore banks of Bell's and Allegheny furnaces, the ore existing apparently at the former, in precisely the same geological relations before adverted to, as marking its situation north of Waynesburg, at the head of the Juniata, in Little Cove, and elsewhere. The ore itself exhibits very nearly the same structure, being dark brown and cellular, the cavities sometimes empty, sometimes filled with clay, sometimes with a loose nucleus or enclosed lump of undecomposed blue protocarbonate of iron. That of Bell's bank is frequently siliceous, though it is productive and yields a good iron. The excavation occurs one mile from the north-west base of Brush mountain. The ore bank attached to the Allegheny furnace is in the same range, about four miles remote from the furnace. This is a much larger excavation than the former. The ore is of the same varieties, embracing, however, a greater proportion of the large cellular lumps. The deepest part of the digging exposes a yellowish, porous sandstone, near the contact of F. VI. and F. VII., with ore infiltered between its fissures. The clay deposites of this synclinal axis have been derived from the disintegration of this soft rock, which is much impregnated with iron. Near Allegheny furnace, another ore bed occurs in the clays of this trough. This consists almost entirely of *pipe-ore*, from which some large and beautiful stalactitic columns have been obtained. The ores of Allegheny furnace seem not to have been produced from the black slates at the base of F. VIII., but rather from the soft yellow ferruginous sandstone near the bottom of F. VII.

The valley between Brush and Allegheny mountains, exhibits some

change in its features, from where the anticlinal axis shows itself.—From M'Cammit's forge or Tyrone Gap, the valley expands by a change in the direction of both mountains, changing from a breadth of two or three miles to one of six or seven miles. It assumes very nearly the character which it has at its other end, near the Susquehanna. Pleasant valley and Logan or Tuckahoe valley, occupy a part of this broad interval. The anticlinal axis elevating F. IV. and F. VII., forms a range of hills or ridges, separated from the Brush mountain by a little valley, and from the slate hills to the north-west, by another; this axis does not extend south-west of Allegheny furnace. Beyond this, the mountains fold over the other or main anticlinal axis of the mountain, at Hollidaysburg, and displays a symetrical and beautiful feature in the topography.

From Allegheny furnace, the belt of hills composed of the limestone and overlying sandstone, after passing Duncanville, sweep in a regular curve south of Hollidaysburg, and take a direction along the south-east side of Brush mountain. Formation VI. is here in its middle beds a pure blue limestone, but partakes near its contact with F. V. and F. VII., of the aluminous character of the former, and the sandy nature of the latter. The limestone, together with the sandstone which it supports, preserve their position in a prominent ridge throughout their course along the north-west side of Scotch valley. About five miles from the river, near the head of this synclinal basin, these strata sweep round to pursue the base of Canoe mountain, in its course to the south-west. Like all the strata near them, they are implicated in the invertion or overturn of that ridge, which we have already more than once alluded to, and appear much contorted at the gap of the Juniata. This disturbed condition of things prevails for some distance along the western side of Lock mountain, until approaching the "loop" the formations become more regular, and curving round at the head of this synclinal basin, they range towards the knob south of Frankstown. Here, as in the case of F. IV., beneath them, they fold over the anticlnal axis, to pursue their course near the base of Dunning's mountain. These formations compose a regular chain of hills encircling the isolated tract of F. VIII., in the centre of this basin of Scotch valley and Old Town Run. The limestone along Lock mountain, is for some distance blended with the slope of the ridge; but where the nearly vertical dip is replaced by a gentle one, a short distance south-west of the river, then the limestone and overlying sandstone leave the foot of the mountain, and form, as usual, a ridge to themselves.

The anticlinal axis elevating the high knob south of Frankstown, overlapping or passing the anticlinal axis of Brush mountain, north of Hollidaysburg, the two form between them a small synclinal trough, in the sandstone F. VII., immediately at Frankstown, in the middle of which, occurs a shallow belt of F. VIII. This collapsed axis extends but two miles north-east of the town, terminating in a little contortion of the limestone, which soon disappears in the general south-east dip of that formation, in Turkey ridge, along the margin of Scotch valley.

In the little belt of slate referred to, should occur the band of iron ore characteristic of the lower part of that formation in other districts, but it is probable that the calcareous and ferruginous layers of the formation, have either been washed away, or did not enter originally as a part of the stratum. The fine grained argillaceous sandstone at the bottom of F. VII., to which we ascribe the ore banks of Allegheny furnace, appears in this neighborhood to be very thin, and almost vanishes as we proceed to the south-west.

Olive Slate F. VIII.

The belt of dark slate, together with the overlying rocks of F. IX. lying at the base of the Allegheny mountain, show a tract of gently rounded hills, divided by irregular ravines. Sometimes these hills form two ranges, separated by somewhat regular hollows; but these uniform features in the topography are not of great extent. The valley of the Bald Eagle creek, at Milesburg, formed by the floods escaping through the gap, is a level plane, for some distance, enclosed between these slate hills and the Bald Eagle mountain. Towards the south-west, the slate hills encroach, and leave but a narrow valley between them and the ridge. This occurs at Hannah furnace, two miles south-west of which, the slate hills lie at the very base of the mountain, in consequence, no doubt, of the vertical attitude of all the strata. Beyond this to the south-west, they again recede, leaving a little valley drained by the head waters of the Little Juniata. A section crossing the slate, and the overlying beds of F. IX., along Wallace's run, exhibits a dip of about forty degrees to the north-west. Further to the south-west, the inclination of the beds is occasionally steeper; but the uptilting of the strata which has brought the slate near the foot of the mountain, does not so much affect it as the other strata immediately south-east, which have passed into a nearly perpendicular attitude. Near Hannah furnace, ten miles from the gap of the Little Juniata, the hills of F. VIII. and F. IX. are higher and bolder than usual. They continue thus until south-west of Bald Eagle furnace, where they recede from the mountain, leaving Logan's valley between. They then become lower, and present gentler slopes. These features extend along Logan and Pleasant vallies, the formation still preserving a regular dip to the south-west, until the whole sweeps over the subsiding anticlinal axis of Brush mountain, four miles south-west of Hollidaysburg. Opposite Blair's gap, the rocks all dip at a moderate angle to the north-west. Near Newrey, we have an anticlinal elevation in the valley between Dunning's mountain and the Allegheny; leaving a trough in the rocks at the base of the former ridge, in the continuation of the synclinal axis of Frankstown. The black slate at the bottom of F. VIII., extends in a narrow belt along this trough to Frankstown, where it disappears.

As before stated, a large tract of F. VIII., occupies the middle of the basin of Scotch Valley and Old Town run. The highest beds of

the formation left in the centre of this valley, are the grey sandstones and dark olive slates of the upper portion of the stratum.

From Newrey southwest, the formation resumes its regular W. N. W. dip, at an angle generally exceeding thirty degrees. The belt has not been yet traced further in that direction than Sarah furnace, in Bedford county. Minute and careful observations were made, with a view to detect the existence of a vein of iron ore analagous to that found in the lower portion of the stratum in Lewistown valley and Little Cove, but hitherto without success. The absence of a visible outcrop of the ore may arise, in part from the non appearance of the narrow trough-like ridges of the sandstone F. VII. which elsewhere sustains the belt of the ore, leaving part of the slate under circumstances well calculated to reveal the bed. The axes of elevation producing that peculiar feature in the topography, are here wanting.

Red Sandstone F. IX.

The red argillaceous sandstones and red slates constituting F. IX. form a belt of rounded and denuded hills, skirting the base of the Allegheny mountain; the whole south-eastern slope of which likewise embraces these rocks, which are only surmounted by the sandstone strata of F. X., near the summit of the ridge. This order of things prevails along the whole escarpment of the mountain, except in the neighborhood of the Blue Knob, the structure of which will be presently explained. From Milesburg for a considerable distance south-west, the hills composed of F. IX, are rather elevated and steep, but as we advance they subside, while the spurs jutting forward from the flank of the Allegheny become relatively more prominent. Approaching Hollidaysburg, the hills at the base of the mountain, consisting of F. VIII. and the lower rocks of F. IX., form a belt presenting regularly rounded and undulating slopes, evincing the enormous amount of denudation to which they have been exposed. The table land of the Allegheny mountain, lying beyond them to the north-west, shows in the same neighborhood, a great number of deep transverse vallies, or long ravines extending down its flank, which have obviously given passage to the retreating floods which scooped the great valley at its base. The promontaries or spurs embraced between these ravines, stand forward from the flank like enormous buttresses or ramparts.

The general dip of the strata at the base, or in the flank of the Allegheny mountain, is from fifteen to thirteen degrees towards the north-west, but at the Blue Knob this state of things is interrupted. An anticlinal axis, ranging immediately at the base of the Allegheny mountain, a portion of the strata south-east of this line, have a gentle dip to the south-east, meeting the north-western dipping beds of the valley between Blue Knob and Dunning's mountain, to form a synclinal trough under the Blue Knob itself. The strata of Blue Knob reposing thus in a basin have escaped the denudation which has removed the more exposed and crushed portion of the formation overlying the anticlinal axis; thus causing a valley between it and the mountain

This structure extends as far as Bob's creek, where the flat anticlinal axis passing Blue knob begins to disappear.

Throughout the long belt here briefly sketched, Fs. VIII. and IX. exhibit great uniformity as respects their composition. The calcareous or cement beds so conspicuous in the lower part of F. VIII., along the valley of the Susquehanna as far as the mouth of Bald Eagle creek, diminish, and almost disappear when we pass to the south-west of Milesburg, and are represented by only a few dark calcareous bands containing sulphuret of iron, and occupying the black slates near the base of the stratum.

Much search was made with a view to discover if the curious red stratified ore which belongs to the lower part of F. IX., at Larry's creek and Pine creek, near the base of the Allegheny mountain, extends to the south-west, but every effort to trace it beyond the neighborhood of Farrandsville, has proved ineffectual.

CHAPTER IV.

Geology of the District north of the Allegheny Mountains, including Lycoming, Clinton, and Tioga counties.

In Tioga, Lycoming, and Clinton counties, our explorations were principally confined to the less inhabited sections lying north of the southern base of the Allegheny mountain. As far as the nature of country would permit, all the coal beds were examined, and their extent ascertained and delineated on the State map. The whole of the coal in this section of the State would seem to be confined to four narrow basins, traversing these northern counties in an E. N. E. and W. S. W. direction, parallel to the range of the Allegheny mountain. The coal within these basins is, however, not always continuous over large areas, but frequently occurs in isolated patches, capping the summits of the higher knobs of the country. As far as we have yet traced them, these basins will be separately described, taking them up in succession from the south east to the north-west, and following each from the north-east towards the south-west. The general and local geological maps, with their accompanying sections and drawings, to appear with my final report, will represent fully the range, structure, and contents of these several basins and detached tracts of coal measures. It is hoped, however, that the following partial detials may be useful without the aid of those important illustrations.

The Allegheny mountain, pursuing a nearly east and west direction through Lycoming county, consists, at its southern base, of the slaty rocks of F. VIII., overlaid by the red shales and sandstones of F. IX. Denuding floods, acting upon these relatively soft materials, have imparted a gently rounded and undulating contour to the surface. Immediately upon them rests the sandstone formation, F. X. of our series, which, by its greater hardness has presented a great barrier to the waters, imparting bolder features and steeper slopes. This rock forms the main escarpment on the south of the Allegheny ridge, in its whole range across the State. The still harder and coarser rocks of F. XII., sometimes capping the mountain, give to it yet stronger features.

Nearly every where along the southern flank of the mountain the dip is northward, or towards its base; continuing thus for some distance, it then changes to the south, and forms a trough in the strata, in the higher tracts of which, we find the southern belt of coal measures. The Allegheny ridge, properly so called, usually embraces along its immediate summit, no stratum higher than F. X. Occasionally, however, it is capped by the coarse conglomorate of F. XII., embracing, in places, a characteristic "brown rock," and in a few knobs, the still higher beds of the coal series, to which the brown rock is an important index. Coal was discovered, and opened during the last summer, on the Allegheny mountain, at a point where the summit, is sufficiently elevated, to embrace all the shale here enumerated. The locality is about eighteen miles from Williamsport, on the old State road, between Newbury and Wellsboro'. Near the base of the mountain were found loose pieces of slaty sandstone characteristic of F. X. Above these rocks, which have a perpendicular thickness of about seven hundred feet, the ridge assumes a more gentle slope, and the soil presents evidence of being derived from the red shales of F. XI. This red shale is probably not more than thirty or forty feet in thickness. It is occasionally very ponderous and highly ferruginous, and shows indications of a bed of valuable *iron ore*, identical, probably, with one discovered in other places. Indeed, ore is said to have been found here. Overlying the red shale occurs the conglomerate, and loose pieces of other portions of F. XII. Its aspect is that of a white siliceous sandstone, imbedding small and scattered pebbles of white quartz. It is nowhere visible in place, and we can only judge of its position and thickness, by the loose fragments. It is probably about seventy-five feet thick. Above it occur no rocks in place; the only strata ascertained, being those developed in the excavations for coal. The following section exhibits the order of things from the top of the highest bench on the mountain, down to the conglomerate:

1st. Coarse micaceous sandstone, containing many vegetable organic remains.

2d. Fireclay,			0	feet,	5 inches.
3d. Coal seam consisting of	coal,				5
"	"	fireclay,			12
"	"	coal,	3	"	2
"	"	shale,			4
"	"	coal,	1	"	8
"	"	fireclay,			3
"	"	coal,			9
4. Fireclay,			6		0
5. Dark fireclay containing *fucoides*.					
6. Coal seam consisting of	coal,		1		
"	"	shale,			4
"	"	coal,	1		
"	"	shale,	2		4
"	"	coal,	1		3
"	"	shale,			1
"	"	coal,			11

7. Black slate containing vegetable fossils, *fucoides, lepidodendron, sigilaria, equisetacea.*
8. Brown sandstone rock.
9. Conglomerate.

This section is compiled from the measurements in several adjacent shafts, in which, it must be observed, the quality and thickness are not every where strictly the same. The main or upper coal seam, extends for more than a mile along a bench or terrace, which serves if carefully noticed, to mark its position. This flat, however, is narrow, the ground sloping rapidly away on both sides down to the conglomerate. Its course is rather irregularly northwards for nearly a mile, when it turns east, and gradually falls away towards Hogeland's run. The southern dip of the coal-measures, soon causes all the coal to disappear as we advance to the north, the red shale of F. XI. coming to the surface and marking the limit of the basin. Beyond these rise the sandstones of F. X. succeeded by the red shales and sandstones of F. IX. the latter constituting the principal part of the hill south of Larry's Creek, and the whole of those lying north of it, in the tract of country known as the Cogenhouse settlement. Excavations were made among the red shales of F. XI. north of the coal, in search of the iron ore which often occurs in this stratum. The shale in some places is exceedingly heavy, containing much oxide of iron; its color is also similar to that of some ores found in the formation, and might readily deceive an inexperienced observer into the belief of its being a productive iron ore. Further explorations, however, will probably result in the development of such in this vicinity.

Eastward the mountain is deeply intersected by the narrow valley of Hogeland's run, to the east of which, on Bope's mountain, exist fair indications of the coal measures, some pieces of the conglomerate being observed on the highest knobs, in a situation indicating the pos-

sibility of coal near the summits. It cannot, however, occupy an extensive surface, though if found, it would derive value from its proximity to the rail road running through the valley of Lycoming creek.

During the season which has closed, no examinations were undertaken further to the eastward along this basin; but coal is known to occur about Bear creek, and Little Bear creek, belonging, no doubt, to the same range. Its examination was deferred to the next season. The dips of the strata along Lycoming creek, indicate that this basin crosses the valley of that stream only a little above the mouth of Trout Spring run.

Towards the west, the mountain falls away to a branch of Larry's creek, called the Roaring Branch, beyond which it rises again to about the same elevation, presenting a flat area of more than a mile square on its summit. The conglomerate rock seems to lie about forty feet below the highest part of the hill, the outline of which is such as to imply the existence of the coal measures. A careful inspection of the surface was made, but no excavations undertaken. Further westward, the hills continue of nearly the same height, but examinations carried on in that quarter about the sources of the western branch of Larry's creek, did not result in the discovery of any coal. A few knobs, each containing a few acres, were occasionally found, possibly high enough to embrace one bed of coal, but they were deemed not of sufficient importance to justify any systematic excavations.

Explorations to some extent were made several years ago, for coal on some of these hills, but all the shafts were dug in the strata below the coal measures, and the highest ground lying in the centre of the trough, were entirely neglected. Excavations more judiciously undertaken, may possibly bring a better coal to light.

The geological map will show the range of the basin from Hogeland's run, across the sources of the different tributaries of Larry's creek, and thence across Pine creek, near the mouth of the First Fork, while the section along Pine creek will exhibit the position of the trough on that stream, and where the coal is to be sought for. In the high tongue of land between the First Fork and Big Pine creek, the hills have considerable elevation. Near the level of the stream, F. IX. just makes its appearance, being immediately succeeded by F. X., which occupies between eight hundred and nine hundred feet of the hills. Above this, the slopes become more gentle, the soil indicating the presence of the red shale. Here a bench in the side of the hill occurs, containing a white sandstone, referrible to F. XII. The rock is without pebbles, being a remarkably white and pure sandstone, readily disintergrating and furnishing a sand that would be well adapted for the manufacture of glass. To this succeeds another band of red shale, and in a high knoll we find another white sandstone similar to that just mentioned, above which are beds of *olive colored slates and*

argillaceous sandstone; holding nearly the position of the lower seam of coal, the existence of which, however, is not indicated. This is about the true place for the coal, if it occurs at all in the region. I would suggest to the owners of lands on both sides of Pine creek, lying a little above or below the mouth of the First Fork, to search for it above the white sandstone of F. XII. in the highest knobs. The lands occupying the head of the north branch of Ramsey's run, being near the centre of this basin, promise best—other things the same, to reward research for coal. Excavations have been made a little above the mouth of the First Fork, by those not familiar with the stratification of the region in a position *below* the rocks of F. XII., thin layers of coaly matter here presenting themselves in F. X. The quantity of dark slate, similar to that of the coal measures, is considerable and it is said, indeed, that a coal seam eight inches thick, was found. The exploration was, however, abandoned; and this will always be the case, when the search for coal is undertaken so far down in the series. On the west side of Pine creek, coal was once worked, for an old furnace near the Jersey Shore and Coudersport road. This tract will be explored during the coming season, though from all that we have this year learned, it cannot prove extensive or of much produtiveness.

The rocks along the Susquehanna river, are the argillaceous sandstones forming the thick bands at the alternation of F. IX. and F. X. dipping at a considerable angle to the north-west. At the mouth of Lick run, these give place to F. X., having its usual characters of a brown slaty sandstone, but containing a few bands of a siliceous conglomerate, somewhat like F. XII., though darker. Above this sandstone lies the red shale of F. XI. in two separate strata, alternating with a grey sandstone, referrible either to F. X. or F. XII. The lowest of these red shales, is a bed sixty-five feet in thickness, containing two seams of *iron ore*, one only about six inches thick, the other twenty feet above it, being about ten inches. The ore is apparently good, but probably, not sufficiently abundant to be valuable.

A similar ore has been discovered on Queen's run, a mile and a-half north-east of the Queen's run mines, where it promises a greater quantity. Between the two seams of ore, occur buff colored and red shales. Overlying this red shale is a thick stratum of grey sandstone, analagous to that of F. X. about two hundred and fifty feet thick. This supports another thinner bed of red shale of F. XI. At the mouth of Queen's run, F. X. contains a seam of fire-clay four or five feet thick, which is a little too sandy, but may be worth working, if mixed with a more argillaceous variety. At the mines on Lick run, the strata have been bored from the highest ground down to the upper bed of the red shale. At different points, where this was done, the strata do not precisely correspond. One of the most important of the beds, a seam of coal is absent over a considerable extent, owing to a dislocation in the strata, or other causes not yet ascertained. In one of the knobs

where the position of the coal appears to be represented by slate and sandstone, we have the following section:

Soil,	1	foot	9	inches.
Rotten coal, which, when under sufficient cover, is usually five or six feet,	1	"	6	"
Soft white clay, in other places worked as a fire clay,	6	"	9	"
Brown slate,	5	"	0	"
In this position should occur a coal seam six feet thick, containing sixteen inches of slate, nineteen feet below the brown slate, but it is absent				
Dark slates and flaggy sandstone,	76	"	5	"
Coal,	2	"	4	"
Dark slate,	9	"	7	"
Coal,	3½ to 5	"	0	"

The above section embraces the lowest coal bed of the basin. It is this seam which is at present principally mined by the Farrandsville company for their furnace, and other works. About fifty cubic yards are mined daily, costing fifty-seven cents per yard for the mining, the small coal not being counted. The coal is coked at the mouth of the mine, being transferred immediately from the cars to large heaps, where it undergoes the coking process without the aid of ovens. It is then sent by an inclined plane and rail road to the furnace at the base of the mountain. The second coal seam in the ascending order is not worked, the coal being impure; but the third, were the ground is sufficiently elevated to embrace it, has been wrought to some extent, yielding a better coal than either of the other two. It is now, however, nearly exhausted. This upper coal seam, lying usually near the surface of the highest ground, has generally an unsound roof, which unfits it to be mined. It measures commonly six feet in thickness. It is now removed to expose the fireclay which lies immediately beneath it, found to be of superior quality for the manufacture of fire brick.—This fireclay, from six to seven feet thick, is destitute of grit, and furnishes an admirable fire brick. Under it lies a bed of shale, containing a layer of *nodular iron ore* of no great purity or richness.

Beneath the lowest bed of coal, slaty sandstone and shales occupy a thickness of forty-six and a-half feet, succeeded by twenty-five feet of red shales, this by upwards of two hundred feet of grey sandstone, and this again by the lower bed of red shale. It is very remarable that we nowhere find the rocks occupying the position of F. XII., possessing the conglomerate character, while in every other neighborhood, in the same basin, as at the first fork of Pine creek and on the Tangascootac, as we shall show hereafter, this rock exists in its true type and features.

At Queen's run the same beds of coal and fire-clay occur which we see at Farrandsville, with this difference, that the uppermost coal seam is here under an ample covering and ranges over a tolerably extensive surface, being the only bed at present mined. Its thickness varies from five feet to three feet nine inches. The coal is superior, and finds a ready market along the Susquehanna.

The *fireclay* at this place is occasionally eight feet thick. A bed of coal about four and a-half feet thick occurs not far beneath it. This does not appear in the coal measures above Farrandsville. The other beds in the series are supposed to occur here, though their existence has not been positively ascertained. At the mouth of Queen's run fire bricks are made to a moderate amount.

They are manufactured at Farrandsville on a more extensive scale: about six thousand nine inch bricks being made every week, commanding about forty-five dollars per hundred. These are at present principally used on the spot for the furnace and other works. The furnace now in operation is built of stone, lined with the fire brick; it is fifty-four feet high. The diameter of the boshes was originally seventeen feet, but was lately reduced to thirteen. A powerful steam engine, having ten boilers, and estimated at one hundred and seventy horse power, when all are in action, propels the blast. From the description given of the coal measures of Farrandsville, it would appear that they furnish neither iron ore or limestone. The ore used in this large and ably constructed furnace, is brought from Montour's ridge, in Columbia county, being the fossiliferous ore of F. V. An inferior species is also procured on Larry's creek from the lower beds of F. IX., the former is transported about one hundred miles, the latter twenty-three miles. The limestone is that of F. II., from Nittany valley. The proportion of the materials employed in making one ton of cast iron, in October last, were as follows:

Coke,	6,500	hogsheads,	2,900 tons.
Fossiliferous ore,	3,200	"	1,428 "
Larry creek ore,	3,500	"	1,562 "
Limestone,	4,500	"	2,009 "

After the furnace had been in blast some time, starting in the month of October last, the cast iron produced was of a superior quality as a foundry iron, the yield being about fifty tons per week.

Passing to west side of the Susquehanna, the coal measures next appear on the Allegheny mountain, on the sourthern side of the Tangascootac creek. This stream runs nearly centrally along the basin for five miles, with a margin of comparatively broad and regular bottom lands on each side. Owing to the greater amount of denudation in the lower part of the valley, the coal measures do not there occur; but higher up they expand over a considerable extent of country, and acquire a thickness of several hundred feet. The growth near the south fork is open, consisting of fine hard wood and scattering white pines, and the surface changes from the steep mountain acclivities, seem nearer the river to gently rolling hills and extensive plains. The rocks along the valley of the Susquehanna for about six miles, belong exclusively to F. X. At the mouth of the creek, this formation rises nearly to the top of the Allegheny mountain, and caps the hill on the north side of the stream. The first appearance of F. XII., is where it covers the eastern extremity of the Allegheny mountain. Tracing it westward, it gradually comes in at a greater distance below the summit, until, three miles from the river, the coal measures occupy the

mountain top, and the white, pebbly sandstone of F. XII. proper, lies under the summit, and crops out high up on the southern side. The hills on the northern side of the Tangascootac, do not reach the elevation of the Allegheny mountain, until we recede several miles, when a change of the dip to the south brings up the lower rocks. Along the northern side of the creek, the knobs are capped by F. XII. as far up the valley as the Forks. A little below this, the coal measures first appear on the north side of the stream, and finally further towards the west, occupy all the high ground between the heads of the two forks, but no coal occurs to the north of the North Fork, the hills then beingcapped by the conglomerate. The most eastern coal beds opened, are south of the First Fork, at an elevation of about 530 feet above the stream, which, in a course of 2¼ miles to its mouth, descends thirty feet. The upper bed lies beneath a thick stratum of brown sandstone. It appears to be four feet thick, but at some distance in from the crop, a fault causes it locally to be only two feet. The quality of this coal is excellent. It is underlaid by a bed of good fire-clay. There occur about thirty-five feet of other strata, covering this bed over an area of perhaps fifty acres. Another coal seam, somewhat slaty, three feet in thickness, lies about thirty feet lower down, at no great distance under which is F. XII., forming a stratum nearly 100 feet in depth. This rock is here a fine sandstone, containing white pebbles, and disintegrates into a fine sand, well adapted for making glass. The next openings are on the south side of the creek, two miles above the Forks. The upper occurs near the top of the hill. It is four feet thick, including some small seams of slate and fire-clay. Over it lies a soft and very tenaceous slate clay, four feet thick. The coal is good; it breaks into rectangular pieces, and contains much mineral charcoal, occasionally in seams nearly half an inchin thickness, showing the fibrous structure of the coal vegetation. It is beautifully marked by thin alternating lamina of dull and splendent glance coal. A bed, supposed to be the same, has been opened at a lower level in a north-western direction, that being the course of the dip. At this latter place, its total thickness is four or five feet, including one foot of dividing fire-clay. Between twenty and thirty feet under this, occurs another coal seam, not well exposed, but apparently two feet thick; upon it rests two feet of fire-clay, and over that one foot of black slate, surmounted by more than ten feet of blue slate. The rocks underneath the coal, are entirely concealed, but the conglomerate cannot be far below. On the southern side of the Allegheny mountain, there are two small *benches* near the summit, at some height above the steep slope, caused by the conglomerate. The lower of these contains the "brown rock," while the upper one, probably, embraces a bed of coal. The hills north of the North Fork constitute the northern margin of this coal basin. They are higher than the hills around, being capped by the conglomerate. Between the north and south forks, coal measures extend through the hills for some distance. Indications of *iron ore* present themselves in F. XI., in a ravine, two miles above the Forks. Between five and six miles from

the mouth, the coal measures are within seventy-five feet of the beds of the streams, the hills rising about 250 feet higher. Further westward, the surface becomes smoother, and the extent of country embracing the coal measures, much greater; but the close of the autumn confined our investigations in this basin, to the neighborhoods already described. The distance across the basin, from the Allegheny mountain to the hills north of the North Fork, is apparently about five miles, but the actual area of the coal is more circumscribed, owing to the numerous vallies of denudation. In the district hitherto explored, the indications of iron ore among the coal measures, are unpromising.

This basin is prolonged, no doubt, across the head streams of Beach creek, and embraces the coal measures at Snow Shoe and Phillipsburg.

Though the eastern extremity of this basin has not been yet explored, we have ascertained with tolerable certainty, that it crosses the Loyalsock, near the mouth of Plunkett's creek. The rocks opposite the mouth of Mill creek, the first large stream above the mouth of Plunkett's creek and along the whole extent of that stream, dip gently to the S. S. E. The conglomerate capping the hills may be traced for miles along their summits. At the very head of Mill creek, the lower beds of F. X. replace it on the hill tops; and below the mouth of that stream on the other side of the Loyalsock, F. IX., rises two hundred feet in the hill, the rest consisting of the flaggy brown sandstones of F. X. In the latter rock occur thin bands of a poor *arenaceous limestone*, hardly rich enough in lime to be of any value. It assumes a singularly pitted or worm-eaten surface from atmospheric action. It is sometimes four feet thick. On the top of the hill above referred to, at an elevation of about one thousand feet above the stream, occurs the conglomerate, apparently about forty feet thick, dipping S. S. E. The summits along the creek were minutely explored, from Mill creek to Lick creek, a tributary of the little Loyalsock, without the discovery of any thing of economical importance.

The topography of this part of the State map is exceedingly erroneous.

A remarkably abrupt anticlinal axis exposing the red sandstones of F. IX., on the stream next west of Lick creek, (another mill creek,) was traced in a west by south direction, crossing Pleasant stream, Lycoming creek, half a mile above the mouth of Pleasant stream and Pine creek, six miles above the mouth of the First Fork, beyond which it deflects a little more to the south, being the great axis separating the Snow Shoe from the Karthaus basins. Nowhere does it exhibit dips so great, as along the waters of the Loyalsock.

The considerable angle at which the rocks dip north of the little Loyalsock, causes nearly the whole thickness of F. IX. to crop out in one hill, though its perpendicular depth is about one thousand feet. The olive and greenish slates of the underlying strata at the alternation of Fs. VIII. and IX. also appear. They have been erroneously fancied to contain *copper ore*. Formation VIII. itself, comes to the surface near the confluence of Mill creek and Lick creek, where it includes

a thin bed of *fossiliferous limestone* of good quality for making lime. Near the limestone, rises a brine spring, the water of which furnishes a blackish sediment, by evaporation.

The bottom lands of the Loyalsock are wider than those on most of the other streams in the northern counties, and contain many good farms. The neighboring hills are precipitous and rocky and remarkable for the distinct features of the *benches* along their sides. Their height varies from a few hundred to a thousand feet; one of them proved to be nine hundred and eighty-eight feet by measurement. In this hill, which is a mile above the mouth of Elk creek on the north side, the strata as far as ascertained, are as follows. For the first thirty feet above the stream, red shales of F. IX. Upon the red shales a blue sandstone. Above this occur flaggy argillaceous sandstones, somewhat reddish, but more commonly blue and gray. The flat loose pieces of this rock conceal most of the lower beds, resting on the side of the hill, although it slopes at an angle of nearly seventy degrees. A somewhat reddish and heterogeneous calcareous rock, in large blocks has fallen a short way down to the water's edge. It is an indifferent limestone, probably unfit for use. At the height of five hundred and sixty-eight feet, occurs a bold bench or perpendicular cliff, formed by a bed of coarse white sandstone and conglomerate, about eighty feet thick, embracing a curious variety of white shale, one foot in thichness. Receding from this escarpment, occurs a shelf or terrace of very gentle slope, from which the hill rises by a steep and regular acclivity to the very summit, which is covered with scattered pieces of coarse conglomerate. This hill and the adjoining rivulets were closely examined, and a few excavations were made without discovering any trace of either iron ore or coal: which latter ought to have presented itself, had the bench described been formed by the conglomerate of F. XII. A band of red shale near the summit, belongs probably to F. XI. and may possibly contain some iron ore. The summit of this hill is a broad flat, used as a pasture, and the only artificial enclosure required for the cattle, is a single bar put across a narrow passage between two rocks.

On the south of Loyalsock, opposite the last hill, a bench exists apparently on a level with the top of this, while a knob forty or fifty feet high rises above it, composed of sandstone and conglomerate.—Under this last bed, is a thin seam of coal, one foot thick, overlaid by a foot of slaty cannel coal, and resting on a floor of black bituminous shale. The same band of coal was readily discovered in other places, at the base of similar knobs in the neighborhood. No iron ore was found. The coarse conglomerate occupies only the very highest knobs. The stratification here described, belongs to nearly all the hills lying on this creek.

Elk Lake is incorrectly placed upon the map; it should be five miles further west, being by the scale of the map one inch out of its true position. The country around Elk creek, consists of Fs. IX. and X. Hogeland's branch traverses the red shales of F. IX., throughout its whole course; it is a rapid stream, descending by a series of water

falls, from twenty to forty feet high, over the harder sandstone shelves, in the red shale. The scenery at some of these waterfalls, is wild and picturesque in in a high degree.

Near the top of the hills around the head of Hogeland's branch, we find a stratum of poor bluish limestone one foot thick, and among the red shale 200 feet lower down, two others belonging to the alternations of Fs. IX. and X. A mile or two east of Hogeland's branch, many loose pieces of the conglomerate are scattered about in large boulders, between the head of that stream and the forks of Loyalsock. The rock is valued by the inhabitants for making mill stones. A knowledge of the stratum from whence they are derived, would prove a guide in seeking for the coal measures.

On the highest parts of Bennett's ridge, at the head of Plunkett's creek, it lies in place dipping N. N. W. four degrees, and under it we find a bed of the red shale of F. XI. It was traced for several miles near the heads of Pleasant stream and Plunkett's creek. At two or three miles below the head of Wallace's run; though the ridge is very high it does not occur. Bennett's ridge runs north-east through Elkland township, south of Pleasant stream: The ridge between Pleasant stream and Rocky run, contains only the lower rocks of F. X. This is about ten miles above Ralston. Between five and seven miles east of Ralston, the conglomerate is well exposed, capping the hills and forming an abrupt or sometimes overhanging wall, twenty-five or thirty feet high, full or dark passages and deep holes. It is not practicable to ascertain the existence of any bed of iron ore which may occur beneath this rock, without a considerable amount of digging. Approaching Ralston, the conglomerate gradually descends lower into the hills, which from the deepening of the valley of the run, has an elevation of at least 1,000 feet above its bed.

Ralston.

The next place of importance to describe, is Ralston, at the mouth of Stony or Rocky run, on Lycoming creek, twenty-six miles above Williamsport, at the present termination of the Williamsport and Elmira rail road. The hills, which are about one thousand feet high, contain, at their base, the red rocks of F. X., surmounted by the conglomeritic limestone. The centre of the coal basin crosses Lycoming creek, near the mouth of Dutchman's run, one mile above Rocky run. The anticlinal axis, causing the southern margin of this basin, crosses near the mouth of Pleasant stream, while the other axis, bounding it on the north, passes near the mouth of Roaring creek. The hills, including the coal measures, occupy a range of country east and west, nearly ten miles in length; but the coal is not continuous over all this extent, being interrupted by deep vallies of denudation. The principal localities of the coal are on a branch of Rocky run, between that stream and Dutchman's run, on Red run, the other side of Lycoming creek, and on Frozen run, near Astonville. From Ralston, a wagon road, at a grade of one foot elevation

to the rod, ascends three miles to the mines. The height of the coal above the creek at Ralston is about eight hundred and seventy-five feet, while Ralston itself lies eight hundred and eight feet above the tide. On Dutchman's run, a remarkable slide in the face of the hill has laid bare F's. X. XI., and XII, On the road leading to the mines, and below the conglomerate, in a bed of dark shale, there is a valuable band of *iron ore*, lying only four feet beneath the rock, from which it is separated by a layer of brown shale. The bed of ore has not been fully exposed; it promises to be about six feet thick. The ore occurs in irregular knotty lumps, closely bebbed in a soft reddish and white shale. It forms about one-half of the stratum, and consists of nearly a white crystaline protocarbonate of iron, somewhat resembling a fine grained sandstone. This is apt to be encrusted with the brown or red oxide. These balls are very solid and heavy, becoming more massive as we penetrate deeper in from the crop. In the other half of the bed, which is principally shale, occur scattered balls of the same ore, of a blotched red and white appearance. This ore is admirably suited for the manufacture of foundry iron. I shall present its chemical composition, when describing it as it occurs on Frozen run, where it is converted into iron. It is contemplated to build a furnace, for smelting this ore, on Rocky run.

The conglomerate and sandstone stratum, of F. XII., varies from forty-five to one hundred and fifty feet in thickness; the top of this rock is marked by a terrace, gently receding from the front of the hill to an abrupt slope, formed by a bed of white sandstone, about sixty feet in thicknees. Between these two sandstone beds we find a seam of rather slaty coal, from eighteen to thirty inches thick, underlaid by thirty inches of slate. Over the sandstone occurs another bed of coal, six feet thick, but not of superior quality, the lower part of it consisting of slaty cannel coal, and the rest being rather hard. It includes two bands of slate, one eight inches, the other near the bottom, three inches thick.

Another coal seam, between two feet six inches, and two feet ten inches thick, occurs seven and a-half feet above the former. It contains three inches of slate near the middle, but supplies an excellent coal for coking, and is much superior to the thicker seam beneath it. Above this coal we find a bed of shale, containing large nodular balls of *iron ore*, the quantity of which has not yet been ascertained; and a little higher, another seam of coal one foot in thickness. Next occur seventeen feet of sandstone, and then a bed of slate, containing balls of good *iron ore*, in considerable abundance. It is thought that this layer may furnish three feet of iron ore. Still ascending, we find eighty feet of brown sandstone, then a fireclay two and a-half feet, and a seam of coal one foot thick, blue slate three feet, brownish, and then white sandstone forty feet, and above this a bed of coal, never fully opened, but stated to be four feet thick, presenting a good appearance at its outcrop. Crowning the highest part of the hill occurs a bed of conglomerate, sixty feet in thickness, less coarse than that of F. XII. The dip of these strata, at the mines on Rocky run, is gently west-

ward on Dutchman's run; on the opposite side it is towards the E. S. E., while a few miles further up the main branch of Rocky run, it is toward to the north-west about four degrees.

A somewhat curious feature in this hill, are the swamps occurring on its very summit; the largest occupying several acres, entirely destitute of timber, and containing a deposite of *peat*, at least fifteen feet in depth. A rare tree, the *rowan tree or witch hazel*, occurs on the borders of these swamps.

On Red run the strata are nearly the same as at Ralston. Beneath the conglomerate, the shale containing the iron ore is thirty-four feet thick, and underneath that is a sandstone one hundred feet, succeeded by another bed of red shale fifty feet in thickness. These two red shales correspond with those at Farrandsville, already described, excepting that the iron ore occurs at the latter place in the lower bed.

Frozen run enters Lycoming creek on the west side, below Rocky run. At a spot called Astonville or Oaksville, a furnace is in operation smelting the ore found in the red shale. The coal measures extend to the head of Frozen run, the mines being on the hill between Frozen run and Red run. The strata here are very similar to those at Ralston, except that the coal beds are not quite so thick. The elevation of the red shale containing the ore is seven hundred and ninety feet above the rail road. The ore band varies from four and a-half to six feet in thickness, the upper half containing the richest ore, which, remote from the outcrop, is nearly solid. Upon it rests four feet of shale. Ascending, the rocks are conglomerate and sandstone, eighty-five feet, coal eighteen inches, brown shale, a heavy bed of sandstone, coal two feet four inches; and a little higher, another coal, eighteen inches producing a good article for coking. This last lies nine hundred and sixty feet above the railroad at the mouth of Frozen run, and the hill rises about thirty feet higher. Near the base of the hill is the usual band of limestone occurring near the top of F. IX. It is too impure to be employed as a flux in the furnace, limestone for that purpose being brought from Williamsport, and employed in the ratio of one ton for each ton of cast iron made.

The furnace at this place is forty feet high, and ten feet six inches in diameter at the boshes. It has been in successful operation only at intervals for about two years; but has recently produced an iron of very excellent quality for foundry use: the castings being highly esteemed.

Crossing Laurel hill by the road up Trout run, a north dip is observed on the south side of the stream, and a south dip on the north side, indicating this as the position of the synclinal axis of the coal basin. Ascending the hill we have indications of F. IX. for an elevation of from three hundred to four hundred feet. This is succeeded by F. X.; on the upper side of which we find the two bands of red shale constituting F. XI. *Iron ore*, in loose pieces, was found near the upper of these beds of red shale, and not far from the summit of the hill, which is surmounted by the coarse white sandstone and conglomerate of F. XII. Above this last rock, one of the lower beds of coal

may possibly exist, where the knobs rise to a sufficient height from this level. Little doubt can prevail, that the red shale below the conglomerate includes a band of iron ore similar to that found at Ralston.

The country south of Laurel hill is extremely rough, being covered by Fs. IX. and X.; but that north of the hill is more gently undulating, F. IX. alone capping the hills and producing a soil fit for farming.—The northern anticlinal axis of the Ralston basin crosses the road a little south of the county line, while the southern axis passes near the head of Trout run.

The next place in our progress west, where this basis contains coal, is on the first fork of Pine Creek. Heavy masses of conglomerate strew the flats along the first fork, about three miles from the mouth of Bear Run, which heads near Larry's Creek. We no longer find F. IX. above the streams, but it rises to their level near the Block House fork, and a little below the old English mills. The hills are between seven hundred and eight hundred feet high, containing about one hundred feet of the conglomerate, supporting one hundred feet more of higher strata. On a stream known as Three Mile, or Porcupine Run, opposite Wolf Run, the conglomerate, and above it, the brown sandstone, are well exposed. Between them no bed of coal was discovered; but above the sandstone, a coal-seam was found consisting of two bands, each about one foot thick, separated by a layer of hard shale. The lower band in this seam is a beautiful black shining coal. Below it lies a bed of hard blue shale. Much search was made for iron ore, but without success. Whether other beds of coal exist in this neighborhood, is uncertain; but the country seems well deserving of further investigation. The conglomerate caps the hills on both sides of the fork, a little distance north and south from the spot where the coal was found. On the east side of the fork, and on the Block House Branch, the indications of coal are less promising than on the west side. An unsuccessful search was made for the iron ore of F. XI. A ferruginous band in the red shale about one hundred and fifty feet beneath the conglomerate, implies that ore might be found here if an adequately minute exploration were made, assisted by proper diggings. Specimens seemingly of good quality were found sticking in the upturned roots of trees between Porcupine Run, and the old English mills.

About the time these discoveries on the first fork of Pine Creek were made, a person seeking for limestone on a wild tract a few miles to the west, stumbled upon a bed of coal: a continuation perhaps of the seam above described. In tracing the basin in that direction, other beds were discovered and opened, to which I shall now refer. The locality is at the sources of Otter, Day's, and English's runs, which empty into the first fork, and of Trout run, which empties into Big Pine Creek, below the second fork; the property belongs to General Keim of Reading. The surface is gently rolling, but very elevated; the obscurity of the exposures, and a considerable amount of dip in the strata, causes the tracing of the coal in this neighborhood

to be rather intricate, as a section made across the basin here would show.

On the very highest lands to the north and north-west, F. XII. either caps the summits or leaves very little room for the "brown rock" which overlies it. A dip to the south carries down these rocks, and soon brings in the coal at a level considerably below the tops of the hills; but the ground continuing to slope also to the south and east, renders it difficult to determine how far the coal extends in those directions. About three miles north on the road towards Babb's, the hill suddenly falls off about two hundred feet, exposing the upper band of F. XI. and the upper part of F. X. brought to this elevation by the southern dip. Still further north, the level of the country is much lower than where F. XII. occurs. Where the road crosses Otter Run, the "brown rock" above the conglomerate just rises to the surface, forming the lower part of the bank; above this is the lowest coal seam, which is two feet six inches thick, containing a thin band of fireclay, and underlaid by another bed of fireclay two feet thick. The outcrop of another coal seam shows itself a little higher up in the same digging. The fire-clay mentioned is of good quality, suitable for the manufacture of fire-bricks. Another coal bed was found twenty-five feet above in a neighboring bench in the hill. It was opened too near the surface to ascertain its quality; its thickness is three feet and eight inches, including two inches of slate. Below it lies a bed of fire-clay, similar to that of the middle coal seam. The extent of this upper bed cannot be great, but the other beds underlie probably fifty acres of surface, or perhaps more.

Tracing the conglomerate towards the north, it appears near the top as a coarse pebbly rock, and lower down, as a reddish brown sandstone. The thickness of the whole stratum is about one hundred and fifty feet. On the northern slope of the hill towards the old English settlement, F. XI. appears. A careful search was here made for the iron ore.—About two hundred feet lower down, the soil indicates the lower red shale bed, and here possibly the iron ore may exist. The hills north-west of the coal openings rise more suddenly, and contain the conglomerate. How much further the coal measures extend towards the south and east, can only be ascertained by systematic diggings and accurate measurement, beyond the resources of the survey. At some places in those directions, the elevation seems to be as great as at the coal, but a change of dip must occur before we proceed far in that course. The brown sandstone is exposed below the coal on Otter run.

Coal may hereafter be found at other points on these high lands between the First Fork and Big Pine creek, but it cannot occupy much extent of surface. It may be worth the attention of the owners of lands lying at the head of the south-west branch of Otter run, about five miles from Callahan's, to excavate for coal, as the appearances here are indicative of the coal measures, and the conglomerate does not reach to the highest summits of the country. Examinations were made here, both for the coal and the iron ore of F. XI. A pit dug in

the red shale about twelve feet, did not, however, bring either mineral to light; but it is probable that the ore exists, if at all, in this neighborhood, chiefly in the lower bed of red shale: for we subsequently found it there on the west side of Pine creek, nearly opposite Callahan's. At this spot it is not, however, well exposed, being only about six inches thick, and composed of hollow ellipitical nodules, containing sometimes an undecomposed blue centre.

Tome's creek enters Pine creek on its west side, heading near the corner of Lycoming county. The anticlinal axis north of the coal basin we have been describing, crosses the main creek just above their junction. Ascending the mountain by a road crossing over to the Coudersport road, the rocks of F. IX. show themselves for the first two-thirds of the way up. Near the top of the formation, we meet with two beds of the *blue calcareous conglomerute*, and another about one hundred feet higher up, among the lower beds of F. X. which continues for one hundred feet more. Above this, we find a bed of iron ore in F. XI. at one time dug in several places. It varies in thickness from two to three feet. From the iron ore to the top of the hill, a vertical space of forty feet, the rock is the white sandstone of F. XII. presenting at the summit many pebbles. Near Herod's, on the Coudersport road, the surface is a little higher than the conglomerate, and consequently a small bed of coal, one foot in thickness, has been found. This coal belongs to another basin lying considerably north of the anticlinal axis above mentioned, and entirely out of the range of the second or Ralston basin. In this neighborhood, the conglomerate and sandstone of F. XII. yield a white sand, which would be well adapted for making glass.

The next coal basin toward the north, or the third in order, is that of Blossburg, on the Tioga river. The hills on the south side of the river, for a few miles above Blossburg, are capped by the conglomerate; the red shale rocks of F. IX. come out on their southern slopes, the dip to the north being considerable. No coal has been found on that side of the river, excepting near Blossburg; though it may possibly exist south of the valley, near its source. The coal formation extends eastward nearly to the head waters of Tioga river, but has not the thickness which it attains further West. On a stream called Little Falls run, nine miles above Blossburg, openings were made some years ago, under the direction of one of the mining companies of Blossburg, developing a seam of coal about three feet thick, and small bands of iron ore. A bed of conglomerate, twenty feet thick, occurs here between the layers of slaty sandstone, dividing this last rock into two portions; the lower one being of considerable thickness, the upper slaty sandstone sustaining the seam of coal. Above the coal rests a bed of black shale nearly twenty feet thick, containing *kidney-formed iron ore* of excellent quality, though not abundant; above which are three layers of a poorer species of iron ore in flat slabs, measuring four inches in thickness. Over the shale with ore, lies a bed of slaty sandstone, extending to the summit of the hill. The dip of the beds at this place, is towards the north. At the eastern side of this hill,

the sandstone forming the summit, containing some small pebbles, resembles somewhat a conglomerate. It includes some small bands of coal.

The next stream towards the west, which furnishes a good view of the strata, is Fellow's run; but no coal has been opened upon it. About three miles above its mouth, this stream descends into a beautiful and picturesque water-fall, the whole height of which, embracing three leaps, is sixty feet. Below the lowest of these, the conglomerate and sandstone rock rises perpendicularly to a greater height than that of the falls. The height of the top of the water-fall or of the conglomerate rock, is about four hundred and thirty feet above the bridge at Blossburg, while the elevation of the same on Morris' run, lying further west, is about three hundred feet. On Morris' run, about three miles above its mouth, at the height of three hundred and twenty-two feet above the Blossburg bridge, a seam of coal was opened some years ago, more than six feet in thickness. It has a roof of fireclay about six inches thick, which must be mined with the coal. Beneath the coal lies a bed of shale, twelve feet thick, said to rest on another seam of coal, probably a thin one; and below this is found a thin bedded sandstone, extending for a moderate depth to the top of the conglomerate. Higher up the run, in endeavoring to remove some of the loose material covering the rocks, a large lump of excellent kidney ore was found, wighing at least two hundred pounds. This had fallen, no doubt, from some bed in the side of the hill. Pieces of coal occur in the swampy ground, but whether they belong to a regular bed, can only be determined by draining and digging.

About forty feet above the large vein of coal, many large nodules of a rich iron ore were discovered among the roots of an upturned tree. Their abundance was such as to indicate a considerable band of the ore. A little lower lies a bed of dark blue shale, enclosing a seam of slaty cannel coal, of unknown thickness. Other beds of coal may possibly have been met with still higher up, or perhaps the exposure seen was only the outcrop of these same seams repeated; little satisfactory information being at present preserved concerning the earlier diggings in this vicinity. The access to these localities, is through a succession of thick woods and tangled laurel swamps; though the country is not unsuitable to the construction of roads.

As some anticipations exist that the coal will be developed in Elk mountain, the southern margin of the basin, it may be desirable to present in this place a general description of its summit. Near the top of a high ridge between the forks of Carpenter's run, a tributary of the Tioga, from the south, occurs a stratum of fine grained white sandstone, which readily disintegrates into good glass maker's sand. Below this, we meet many loose pieces of conglomerate, which occurs in place 100 feet higher up, constituting benches within fifty feet of the summit, and about 500 feet above the Tioga river, This rock is about fifty feet in thickness, being in some places a coarse conglomerate, in others passing into sandstone. This bed caps the whole ridge opposite the mouth of Fellow's run, for a mile or more back from the

river. Its dip is towards the N. N. W. The same rock has been encountered further east on the same side of the Tioga, forming the summit of the hills. It is in vain therefore to look for workable coal in these positions; the most that can be hoped for, being a small imperfect seam, occasionally found beneath this stratum, about ten inches thick.

The rocks in the bottom lands along the river above Blossburg, belong to F. X., and contain some layers suitable for whetstones. Formation IX. does not show itself.

Coal run, upon which some of the mines above Blossburg are situated, enters the Tioga from the north-east. Its source is not quite a mile from the river. The hills around it are 400 feet above Blossburg, A nearly continuous section of the strata was obtained on this run. The highest bed measured, is at an elevation of about 284 feet above the river, above which occurs a considerable thickness of rocks without exposures.

Section at Coal Run.

Brown sandstone,		
Kidney ore, shut out by the sandstone,		
Shale, a thin bed,		
Coal, chiefly cannel coal,	3 feet.	
Fireclay,	2	6 in.
Shale,	15	
Coal,	1	6
Fireclay,	2	6
Shale,	2	
Nodular ore,		4
Blue shale,	3	
Coal,	3	6
Fireclay,	2	6
Shale,	10	
Sandstone with vegetable remains,	30	
Fireclay,		6
Cannel coal, with two seams of slate, one 1 foot the other 3 inches thick,	2	7
Shale, containing rich kidney form ore, the aggregate thickness is about 6 inches, all lying within 3 feet,	32	
Coal *too far below* the ore to be worked with it,	1	
Sandstone,	30	
Cannel coal,	2	
Olive colored shale,		
Sandstone with vegetable remains, passing into a conglomerate towards its lower part.		

Below these strata, we meet with the red shales of F. X., alternating with sandstone. Diggings have been made in this red shale, for

iron ore, two unimportant bands of which were discovered. Near the upper red shale, is a bed of fireclay.

The next vertical section measured, is on Bear Creek, north of Coal Run, but on the same side of the river. A thick bed of sandstone, part of which is pebbly, and about fifty feet thick, forms the upper rock in this hill, above the coal-mines. The following series, commencing a few feet below the bottom of this rock, exhibits the composition of this hill:

Coal, variable, but sometimes	1 foot,	6 inches.
Shale, containing four inches of iron ore, ten to twelve feet,	12 "	0 "
Coal,	3 "	7 "
Fireclay, two to three feet,	3 "	0 "
Coal, lower half cannel coal,	1 "	2 "
Dark sandstone, with purplish stripes,	12 "	0 "
Coal,	1 "	6 "
Stratum not measured,		
Sandstone, imbedding pebbles,	30 "	0 "
Bed containing iron ore, three to five feet,	4 "	0 "
Stratum not measured.		
Sandstone.		
Stratum not measured.		
Red and yellow shales of F. XI.		

The upper coal occurs on the south side of the creek, where it is one foot six inches thick; but on the north side, it is entirely wanting. The ore in the next stratum is good, but small in quantity; this bed is also visible on Coal Run. The next bed is the main coal seam at Blossburg; it has been opened in five different drifts, two on the south side and three on the north side of the creek, at an elevation of about two hundred and eighty feet above the rail road, not quite a mile distant. The quality of this coal is somewhat injured by the amount of sulphuret of iron occasionally present, from which the chief part of the bed is comparatively free, having a fine brilliant lustre. A fault crossing the three drifts on the north side of the creek in a north-east and south-west course, throws down the coal three feet. Large quantities of this coal are carried down the Tioga valley in the winter.—

The fireclay under this coal contains fossil-stems of the genus *cactus*. At its outcrop occurs a large deposite of exceedingly tough clay, derived from this bed, well adapted for the manufacture of fire-bricks. The eighteen inch seam of coal was at one time partially mined, but has since been abandoned. The sandstone which underlies this, is rather remarkable, passing in its lower beds into a coarse conglomerate. We have not yet determined whether this bed marks the bottom of the coal measures. Under it lies another bed of sandstone, and beneath that the red shales of F. XI. Below the conglomerate, a rather singular band of ore has been met with, which thinned out after being pursued for a few feet in. It would justify further exploration. The shale containing this ore is nearly five feet thick, consisting largely at its outcrop, of long elliptical balls of a very argilla-

ceous brown ore, lying closely adjacent to each other, and forming more than one-half of the stratum. Each elongated nodule, consists externally of a series of concentric crusts, which readily peel off by exposure to the atmosphere. Beneath the balls, lies a nearly solid layer of a heavy yellowish-gray ore, about six inches thick, having a true oolitic structure. These beds appear to be shut out by the overhanging sandstone, at a short distance in from the surface. Other excavations have been made for ore in the other red bands lower down in the series, but unsuccessfully. The conglomerate and sandstone of the two beds described, strew the hill-sides in great quantity, and furnish an excellent building material.

Half a mile north of Bear Creek and parallel with it, is the denuded valley of East Creek, on the northern side of which the hill is capped by a thick bed of sandstone passing towards its lower part into a conglomerate. Underneath this lies a stratum of brown shale, fifteen feet thick, containing four bands of nodular ore, included in a thickness of seven feet of shale, the aggregate thickness of the ore being thirteen inches. This bed of ore is the most promising hitherto met with in the region. The chemical composition of this ore will be seen in Cap. VI.

Below the shale is a thin layer of sandstone; then a black shale, including a thin seam of cannel coal; and fifteen feet under this, it is said another seam of ore occurs fifteen inches thick; and beneath it again a bed of coal twenty-one inches in thickness.

A considerable southern dip occurring between East creek hill and Bear creek hill, the sandstone capping the summit of the former, is probably the same as that which underlies the coal openings along the latter. On Limestone Hill, half a mile further north, the highest rocks are the thin beaded sandstones of F. X. extending from within two hundred feet of the base to the summit. At its base the limestone so often found, at the alternation of F. IX. and F. X. shows itself, with a thickness of at least eight feet, consisting of heterogeneous materials, closely cemented by calcareous matter. It has a variegated aspect, like certain *breccais*. It is a durable rock, well adapted for building stone, but it is too impure to be converted into lime. It is underlaid by a blueish, micaceous sandstone, furnishing an excellent building stone. The dip here is at an angle of five degrees towards the S. S. E. North of Limestone Hill, some of the lower layers of F. IX. appear above the bed of the valley. In one particular band of red, micaceous sandstone, occur numerous mutilated remains of a highly curious fossil fish, *the Holoptychui of Agassiz*. Further north, still lower rocks appear.

On the west side of the Tioga river between the heads of Johnson's creek and Boon's creek, three miles from Blossburg, the coal measures occupy the hills, though little is known of them at this locality. The following account of the stratification on Johnson's creek, was furnished by the superintendent of the mines at Blossburg. Near the summit occurs a shale containing nodular iron ore; below this, a bed of coal two feet two inches thick; then fifteen or twenty feet of sand-

stone, then another coal seam embracing two feet five inches of coal, fifteen inches slate and twenty-two inches coal; in all, a bed about six feet in thickness.

On West Hill near the mouth of Johnson's creek, there is a sandstone passing into fine grained conglomerate about fifty feet in thickness, underlaid by four feet of olive colored shale, containing about two feet in the aggregate, of *iron ore* near its outcrop. The lower portion of this ore is of a greenish gray color; the upper is reddish, and sometimes oolitic in its structure.

At the outcrop, the greenish gray kind is one foot four inches thick, the red ore nine inches. The whole bed shows signs of diminishing in thickness, when followed in towards the hill, but possibly it may again augment. At the foot of the hill a considerable deposite of *bog ore* has been collected, apparently from this stratum.

From the foregoing remarks, it will appear that the principal supply of coal at Blossburg, must come from one seam, and that this occurs in greatest thickness on Morris' run, six miles from the village where it is about six feet from floor to roof. No bed of iron ore has been yet discovered, which will justify, I conceive, the construction of a large furnace, though some of those already opened may prove sufficiently productive when further explored.

Crossing this coal basin at a point further west, in a south-east direction from the south-west corner of Charlston township, the following features present themselves. The hills in this part of the township are capped by F. XII., the material used in the construction of the Court House at Wellsborough. Passing south-eastward crosses the forks of the First Fork or Babb's creek, the conglomerate is seen to occupy the tops of all the high ridges, being no where met with below the summit. The upturned roots of the trees furnish no indications of coal smut. Southward to the head waters of the First Fork, near the Blossburg road, the conglomerate caps the summits. In so wild a country, it is impossible always to pronounce with positiveness upon the non-existence of coal in a part of the basin like this, where a slight dip may bring in, unperceived, the lower part of the coal measures. This neighborhood was carefully examined, and if the coal does prevail, it cannot cover much extent. Further west over Wilson's or Yarnall's creek, entering the first fork at Baab's, and heading towards Wellsborough, the coal measures have been discovered, and the coal opened on the west side of the stream. On the east or opposite side, coal smut was also found by us at the mouth of Wilson's creek. The dip is gently northward; and about five miles above or towards the north, it is southward, forming the basin, in the centre of which lie these insulated patches of coal measures. The tops of the hills at the two boundaries mentioned, consist of the conglomerate, on the very highest knobs or the brown rock above it; gradually descending to a rather lower level in the basin, they have over them for a considerable extent of surface, a moderate thickness of strata, which may be found to contain one seam of coal. Between one hundred and two hundred feet below the conglomerate, there occur abundant signs of a bed of

iron ore, visible along the brow of the hills on each side of Wilson's creek. Some amount of excavation, however, would be requisite to develope it. Along Wilson's creek, F. X. is not very thick, the hills containing the coal measures being apparently not more than six hundred feet high, while F. IX. just appears above the bed of the valley. The coal occurs between two and three miles above Baab's, at the mouth of Wilson's creek. It overlies a bed of sandstone reposing above the conglomerate. The floor of the coal is a dark brown shale. The seam is double, the upper portion being one foot in thickness, the lower, eighteen inches, both of good quality. They are separated by a band of dark shale one foot in thickness; the roof of the coal bed consists of black shale full of vegetable fossils. The hill rises only about thirty feet higher than the level of the coal, and presents no indications of another seam, or of a band of iron ore, though much search was made. Half a mile north from the opening made in the coal, the conglomerate rock is finely exposed, exhibiting itself in a bed of about thirty-five feet thick. Receding a little from the front of the hill, a bench rises about thirty feet from the conglomerate. On the top of this flat the upturned roots of the fallen trees, disclose numerous fragments of iron ore. The indications of ore are tolerably abundant from this point across to the Stony Fork, and the smut of the coal is also traceable throughout the same tract, but whether more than one coal bed occurs, cannot be ascertained without much excavation.—The conglomerate lies high, but some points of the surface tower a little above it. The outline of these high lands is undulating, the growth is open, and would furnish much timber adapted for making charcoal. On both sides of the Stony Fork the conglomerate crowns most of the hills until we advance several miles up the stream, where the lower rocks form the surface. This formation is well exposed in this vicinity, forming often an irregular line of escarpment around the brow of the hill for many miles in extent, where enormous blocks, dislodged from the stratum, open lanes and passages between them and the main bed. In the bed of the valley of Stony Fork, the impure, calcareous rock near the top of F. IX. sometimes shows itself. About three miles from the mouth on the east side, a very ferruginous spring appears, depositing a large mass of brown ochre. A little above this spring, an excavation was made in search of ore, and a band of small compact nodules, whitish within and coated with a brown crust, was found, imbedded in a shale. After penetrating to a depth of a foot and a half, a copious ingress of water arrested the digging. This band of ore, is conceived to be a continuation of that already discovered in so many places in F. XI. The same band was found some years since, several miles to the west, on Pine creek. On the west side of Stony Fork, the red shale below the conglomerate is very ferruginous.

Between the layers of the conglomerate, a short distance from the bottom, a thin band of black shale, readily mistaken at first for the crop of a seam of coal, was found. As it is somewhat continuous, though only one foot thick, it is desirable thus to mention its position,

lest it may mislead. Over the conglomerate on the same side of the stream, the ground rising twenty or thirty feet, a few pieces of kidney ore were discovered. Diggings being made, the bed, however, proved to be thin and irregular, being a band in the brown sandstone. Signs of the same seam were met with in other places, in a corresponding position in the strata, but no where gave promise of being productive.

At the mouth of the second fork of Pine creek, the rocks dipping gently to the north, F. IX. extends from the bed of the valley a considerable way up the hills, the conglomerate capping only the highest knobs, and no coal measures appearing above this along Pine creek. The only chance we have of finding them is above the head of Elk run, entering Pine creek a mile and a half above the mouth of the second fork. Here a bed of iron ore was opened a few years ago, below the conglomerate, being probably the same found upon Stony Fork. It was mined for a short distance in by a regular drift, and proved to be between three and four feet in thickness; the whole of which, however, is not ore, a portion consisting of imbedding shale. On Big Pine creek, about four miles above the mouth of the second fork, the rocks, previously nearly horizontal, dip south, bringing in the conglomerate on the summit of the hills, about two miles below this on the east side of the stream. This very shallow basin in the rocks will, therefore, probably not yield any coal along Pine creek.

Retracing our way eastward to the Tioga river, these southern dips are seen to continue from the northern margin of the Blossburg basin, down the stream to a point about midway between Covington and Mansfield. The hills here are low and gently rounded, and consist only of the beds of F. VIII. At Covington, they are capped by F. IX. A band in F. VIII. has been found sufficiently calcareous to yield lime. It is full of fossil shells. North of the flat anticlinal axis between Covington and Mansfield, the northern dips bring in F. X., which caps a belt of higher hills ranging north of the latter town. The dip again changes to the south, about two or three miles north of the mouth of Mile creek, and continues southward as far as the northern boundary of the state. Tracing the anticlinal axis which divides the Blossburg coal measures from the northern unproductive basin, we find it bringing the rocks of F. VIII. to the surface, along the whole belt of country crossing Wilson's creek, Stony Fork, and Big Pine creek, near the Round Island. The gentle depression of the strata to the W. S. W., causes all but the very upper layers of F. VIII. to sink out of view on Pine creek. The calcareous, fossiliferous bands of this formation, occur on Stony Fork, but afford a very indifferent lime. Near the brink of this stream in the alternations of F. VIII. and F. IX. issues a small saline spring, capable of affording a bitter salt. Some years since, an attempt was made to bore for brine at this spot, and the strata were penetrated to the depth of about three hundred feet without procuring and further supply, when the augur broke and the work was given up. The true saliferous rocks of our state are much higher in the series, being the white and porous sandstones of the lower coal measures and of F. XII., and these are

never productive in brine, unless when they occur at a considerable depth below the beds of the vallies.

On the Tioga river, the northern dip, carrying down the rocks of F. VIII., forms a broad but shallow basin between Mansfield and the mouth of Mile creek. The Tioga river crosses the bottom of this basin above Tioga village, displaying the rocks of F. IX. Receding from the river, the hills are capped by F. X.; and it has been said that the very highest knobs take in small patches of F. XII. Denudation has, therefore, swept away every remnant of the coal measures which may once have occupied the centre of this trough.

Tracing this northernmost basin westward, we find it crossing Crooked creek, a little north of the Big marsh. The hills bounding it on the north and south being capped by the F. X., the gray slates of F. VIII. appear in the valley between. The town of Wellsborough lies in the latter formation.

About eight miles northwest from the Big Meadows, occurs a bed of iron ore, from which a large deposite of brown ochre has been produced. Much ore has been taken from this spot. The ore band has not been fully developed. It occurs within one hundred feet of the summit of the hill, lying probably below the conglomerate, though that rock does not appear. About two tons only of loose, nodular ore have been excavated. Twenty feet below this bed, a bench or broad terrace occupies the flank of the hill, embracing about twenty acres of surface. It is covered by a rich deposite of the bog ore, to a depth averaging perhaps two feet. Higher on the hill a small seam of coal, one foot in thickness, occurs, which is of limited extent. Near the summit of the hill, are indications of another bed of iron ore.

CHAPTER V.

Sketch of the Geology of that part of Western District of the State which embraces the counties of Armstrong, Clarion, Venango, Butler, Beaver and Mercer.

Though the bituminous coal measures of our state constitute, in strictness but one group of sandstones, limestones, shales and coal seams, not susceptible of any *natural* sub-division, the expediency of adopting some classification of so extensive and complicated a system of rocks, induces me to separate the whole, into an *upper* and *lower* series, and to designate these by the geographical regions which

out, and occurring, at intermediate points, much lower than a regular dip would carry it.

The variegated shale composing No. 1 of the Monongahela series, is found at the base of all the hills surrounding Pittsburg, and is completely exposed on the river as far as Sharpsburg. Here the hills consist of the same rocks as at Pittsburg, but the shale is higher, causing the Pittsburg coal to be found only on the highest knobs, while the first two strata of the present series begin to show themselves in the lowest places. The sandstones No. 4 and No. 5 of the Monongahela series are here quarried, while the colored shales above them are all well exposed. At Fairview, five miles higher up the river, we find the hills about three hundred and fifty feet high, and too low for the Pittsburg coal; while the colored shales of the Monongahela series compose the upper part of the hills, forming a compact bed one hundred and seventy feet above the water, resting on No. 4 and No. 5 of that series. The bed No. 5 is a compact sandstone, quarried extensively at Alexander's quarry, one mile above, and also at numerous points on the other side of the river. When we arrive at Tarentum, we find that still more of that series has vanished, including the above sandstones. The river hills average two hundred and fifty feet, while the coal, No. 6 of the Allegheny series, has just made its appearance above the canal, with the accompanying strata. At Freeport, the hills are composed almost entirely of the same strata, their denuded summits being in a few instances formed by the colored shales and slaty sandstones of the Monongahela series, while at Kittanning we see at an elevation of one hundred feet the fossiliferous limestone and other rocks which were far beneath the river level at Freeport, and the last remains of the Monongahela series are indicated by the red and variegated shales which cap the high hills on on both sides of the river.

No. 1.—Slaty Argillaceous Sandstone.

Commencing our enumeration of the rocks of the coal measures, with the first bed immediately beneath the red and blue calcareous shale lying at the base of the hills around Pittsburg, we meet with an unimportant and somewhat variable stratum, first well disclosed at the mouth of Cirties' Run, and Pine Creek. It consists of a light greyish slaty sandstone, generally in thin layers, and usually in a fragmentory condition wherever it has been much exposed. The beds numbered 1, 2, and 3, in the Pittsburg, or Monongahela series, described in my last report, conceal this rock along the river from Pittsburg to Sharpsburg. Beyond the point where it emerges, it is quarried in several places, but is generally too soft to be a useful building stone. It forms the bed and margin of Pine, Deer, Sandy, and Plum creeks, and is also visible on Saw-mill Run, Cirties' and Higby's runs, and in most of the ravines along the river hills between Pittsburg and Tarentum. At Freeport, and in the neighborhood of Kittanning, the true position of this stratum should be on the summits of the very

highest hills. From all those of less height, it has been removed by denudation. Gradually thinning out in this direction, it becomes indistinguishable from the inferior strata. Average thickness thirty feet.

No. 2.—Shale.

The argillaceous sandstone just described, is seen to be underlaid by a bed of yellow and brown shale, into which it gradually passes, and which indeed is merely the inferior portion of the same deposit. This is exposed along many of the streams and ravines above referred to. We detect it at Freeport, resting upon the thick sandstose which overlies the upper coal seam at that place. Near Kittanning, it occurs on the river hills in contact with the small bed of coal to be next mentioned. Iron ore has not hitherto been noticed in this shale in any quantity. Thickness in considerable.

No. 3.—Coal.

A seam of coal, about one foot thick, overlaid by the above shale, shows itself in the river hills fifteen miles above Pittsburg. It is not recognized again until we approach Kittanning, where a band of coal identical with it in position as far as can be ascertained, has been opened near the summits of the hills. At Allegheny furnace, it is two feet thick, but not of sufficient value to lead to its being mined. This seam of coal has been particularized chiefly with a view to prevent persons from confounding it with workable seams situated lower in the series. It ranges westwardly to the vicinity of Butler, where it could probably be detected, were it of sufficient value to justify a minute exploration. It is prolonged, likewise, through the north-west corner of Westmoreland county.

No. 4—Sandstones and Shale.

In this division are embraced some beds which are peculiarly interesting, as they produce a marked influence upon the physical features of the district where they appear. Their variable character tends at the same time, not a little to embarrass the geological inquirer. While the coal seam, and beds of limestone, are traceable with comparatively little modification of aspect or composition, over an extensive range, these intrinsically less useful strata, are much less easily followed. Being more or less irregular accumulations of sand and clay somewhat promiscuously deposited by conflicting currents, a considerable diversity of composition, is apparent wherever we compare them at distant points. Throughout the coal measures generally, the sandstones vary in appearance, when traced sometimes only a few feet, and often thin out entirely in the distance of a few miles, beds of shale, totally different in their nature replacing them.

Overlying the upper coal seam on the Allegheny river below Free-

they occupy. The two chief rivers which traverse the basin, flowing in opposite directions, intersect wholly different strata, the Monongahela and its western tributaries passing through the upper coal measures, and the Allegheny through the lower. Starting from the marly shales exposed at the water's edge at Pittsburg, and ascending the former river, we rise into higher and higher layers, and following its western streams into Wayne county, we may even reach the uppermost beds of the whole series. Ascending the latter river on the other hand, we come upon lower and lower rocks, emerging successively to view, until, in the neighborhood of Franklin and Warren, we encounter those that form the bottom of the basin. I propose, therefore, to call the upper coal measures exposed in the valley of the one river, the *Monongahela Series*, and the lower strata, as they are developed in the valley of the other, the *Allegheny Series*. The Monongahela series includes the beds entitled the *Pittsburg Series* in my last annual report.

When the task of tracing the range of the several strata throughout the whole coal basin shall have been completed, and the respective areas of those two divisions of the formation ascertained, the Monongahela series will be found not to extend beyond the limits of Allegheny, Washington and Green counties, the southern townships of Beaver and Armstrong, the south-western ones of Indiana, and all those sections of Westmoreland and Fayette lying north-west of a line near the base of Ches nut Ridge. All other parts of the general coal field situated to the north-west of the Allegheny mountain, are occupied by the Allegheny series to be here described. The boundary between the two series marked by the final outcrop of the shales which are exposed just above the Ohio river at Pittsburg, will not deviate greatly, when ultimately traced, from a line ranging as follows: Commencing at the Ohio river, near the mouth of Yellow creek, and running thence nearly eastward, it crosses the same river again near Economy, and the Allegheny river about the mouth of Bull creek, then deflects a little to the north, passing the Kiskiminitas a few miles above its mouth, and ranging north of Crooked creek, which it also crosses. Assuming a nearly eastern course, it runs north of the town of Indiana, near which it sweeps to the south and south-west, and then follows the base of Ches nut Ridge and west Laurel Hill, to the Maryland line. The country south and west of this boundary is occupied exclusively by the Monongahela series.

Coal Measures.—*Allegheny Series.*

Description of the Lower Coal Measures as they occur between Pittsburg and Warren, on both sides of the Allegheny River, adopting the descending order and proceeding Northward.

Having in my last annual report enumerated and described the various beds of the bituminous coal measures of the western counties of the State, which compose that part of the series overlying the

lowest stratum exposed at Pittsburg; I propose in the present place to give a similar account of those layers embraced between the same stratum and the sandstones and conglomerate at the bottom of the coal formation. To render this enumeration more intelligible, I shall commence at Pittsburg, in the neighborhood of which the strata are well exposed and familiarly known, and discuss them in the *descending* order as they rise in succession to the level of the Allegheny river between that town and Warren, this being the order of their outcrop from the centre towards the margin of the basin. While specifying the features and composition of each division of the series as it appears adjacent to the Allegheny river, I shall also refer to it in other places, in order to show its range both east and west of that great intersecting valley; but the confined limits of an annual report, and the unfinished state of the geological map, will prevent my attempting to delineate the outcrop of each stratum, or to introduce more than a few localities at which it may be seen. The intelligent reader, *with the Map of the State before him*, will, however, be enabled, it is hoped, with the assistance of these localities and the descriptions given, to trace with sufficient accuracy the range of each important coal bed and other sub-division of the series.

It may be proper in this place to offer some explanatory remarks in reference to the strata exposed on the Allegheny river, between Pittsburg and Freeport; a clear understanding of which will render intelligible to the most cursory observer, the general range and nature of the rocks comprising the northern half of the great western coal basin. The variations in the shales and sandstones present occasionally great difficulties in identifying them. It should be remembered, also, that the divisions of the strata adopted in my reports, though rendered necessary by the nature of the coal measures, are, in fact, more or less arbitrary divisions, which exist with rather less distinctness in nature than might appear from the definite limits assumed for sake of description. Hence, a practical observer, not conversant with geological research, may err in comparing our general accounts with the exposures in some particular neighborhoods.

While the rocks composing the present series are all under the Ohio at Pittsburg, and rise and crop out successively towards the E. the N. E. the N. and N. W., forming an eliptical basin, their dip is by no means regular, but *undulates* considerably, the local inclination differing in a multitude of cases from the general one. Thus, below Freeport, at some of the coal mines, the *local dip* is up the river, while in fact the *general dip* is in the contrary direction, as is shown by the coal cropping out on the north and sinking under the Ohio to the south. The coal vein just described makes its appearance on Pine creek, owing to a local rise in the strata, while it does not show itself above the Allegheny until within a few hundred feet of Tarentum. At Pittsburg it appears to be from one hundred to one hundred and fifty feet below the river, while at Freeport it has the height of one hundred and forty feet above the water. At Kittanning it is still higher, rising further north to the tops of the most elevated hills, and finally cropping

ty, and through portions of Allegheny and Beaver counties, disappearing ultimately beneath the Ohio river, in conformity with the general south-western dip of the coal measures. Near the town of Butler, where it is extensively wrought, it holds a high position in the hills. It is here four feet in thickness. It occupies a lower level on the lands of Alexander Boyd, in the north-west corner of Middlesex township, half a mile east of the township line. The general surface of the country throughout Mercer, Venango, and part of Slippery Rock townships, in this county, is not sufficiently elevated to embrace this number of the series: the fossiliferous limestone, presently to be described, constituting one of the upper rocks, throughout this district.

Ascending the Kiskiminitas, this stratum of coal is wrought in many places until it is hid below the level of the valley.

No. 7.—Non-Fossiliferous Limestone.

Supporting the above coal seam, is a bed of limestone, the true position of which is a few feet below the coal, separated from it by a soft shale, and sometimes by a hard, black, bituminous slate, containing vegetable impressions. Below Freeport, where this stratum first emerges from beneath the level of the streams, it consists not of a compact bed of limestone, but of loose nodular masses of that rock, irregularly imbedded in shale. These are very hard and fine grained, and of a light blue color, and conchoidal fracture, affording a strong but ash colored lime. Proceeding towards the north and east, the bed acquires greater compactness, and becomes valuable as a source of fertility to the soil, upon which, unfortunately, lime is not sufficiently employed.

This limestone bed occurs at the hills near Kittanning, and also on those around Red Bank and Mahoning creeks. At the mouth of Sugar creek it occupies the summits of the river hills, where it is overlaid by the coal seam, No. 6, separated from it by a calcareous shale three feet in thickness. The stratum is here four feet thick, excessively hard, of a dark blue color, and very pure. Throughout the eastern part of Armstrong county, it is traceable from the Kiskiminitas to the north side of Red Bank creek, becoming a peculiarly solid and compact bed, in Pine, Wayne, and Red Bank townships. About one mile south of Mahoning, it is opened on the farm of Mr. Peter Lais. Near the village of New Bethlehem, it shows itself on the lands of Messrs. Henry Doverspike, Thomas M'Kelvy, and others, being a hard, dark blue rock, containing only a few fossils.

Westward from the Allegheny river, it ranges in common with the overlying coal through the central parts of Butler county, cropping out on the north and west. It was discovered by us at the town of Butler, where, strange to say, it has not been wrought. It is from this stratum that the central townships of Butler county will be supplied with lime, as soon as the importance of calcareous manure

shall be duly appreceiated. Here its value is enhanced by the argillaceous, ferruginous character of the soil, rendering lime especially beneficial. Through a remarkable oversight, the existence of this stratum is hardly known to the inhabitants who derive their chief supply of lime from a bed of inferior quality, No. 15, of the series, hauling it a considerable distance. It undoubtedly extends through Middlesex, Butler and Centre townships, and parts of Cranberry, Muddy creek, and Parker townships, in the latter of which, it is opened near the village of Fairview. Its proximity to the coal will not only facilitate its convertion into lime, but readily lead to its discovery, its proper situation being under the coal seam, No. 6, of the series, either in contact with it, or separated by a few feet of soft shale. It does not always occur as a compact bed, but assumes this condition as we approach its outcrop, agreeing, in this particular, with the overlying coal.

This limestone should not be confounded with the fossiliferous limestone, to be hereafter described, which, entering the river hills below Kittanning, shows itself on Buffalo creek, passes under the table land of Butler, and ultimately re-appears on Muddy creek and Slippery Rock. That limestone must lie at least two hundred feet below the level of the Conequenessing, at the town of Butler. The bed before us is distinguished from it, by rarely containing any *fossils*, although these occasionally occur in the brown calcareous shales which divide it from the overlying coal. We ought to mention that its surface frequently presents blotches of a different tint from that of the surrounding parts of the rock. These may readily be mistaken, by the inexperienced observer, for minute fossils. Thickness from three to six feet.

No. 8.—Slaty Sandstone and Shale.

Underlying the limestone, we usually find a bed of sandstone interstratified with shale, but varying much in composition. The sandstone occurs in layers from six to twelve inches thick—sometimes in contact, sometimes separated from each other by shale. This latter is generally brown, and often breaks into thin splints. In other instances it is compact, and contains a considerable quantity of nodular iron ore. At Freeport, the stratum is fifty-one feet thick; at Kittanning, forty-two feet. Average thickness about fifty feet.

No. 9.—Coal.

The next bed in the descending order is a seam of coal. This is remarkably variable. It appears above the level of the Allegheny river, about two miles above Tarentum, and is wrought at Morrison's salt-well, where it affords a good fuel. The bed is remarkably irregular as regards thickness, measuring in some places four feet; in other places only two feet. We may trace it from this point to the mouth of the Kiskiminitas, where a thin layer of soft bituminous shale, mixed

with coal, supplies its place. A similar condition of things exists at Leechburg. This coal seam, at Freeport, lies at an elevation of fifty-seven feet above the level of the river, and at a considerably greater height at Kittanning. A bed of coal, believed to be the same, appears on the Conequenessing creek, near the village of Harmony, where it is opened on the land of Jacob Ziegler. It is here of good quality, varying in thickness from two and a-half to three feet. It is also opened at Zelienople. This coal is remarkable for its irregularity, not only as respects its thickness and local dip, but as regards the nature of the accompanying strata.

No. 10.—*Sandstone.*

Beneath the above coal—sometimes in contact with it, sometimes separated by soft shale—occurs a thick bed of sandstone. This is remarkable for its variable dip and composition, the layers being often curiously contorted, apparently from their irregular mode of deposition. It contains numerous vegetable impressions. Along the Kiskiminitas, between Leechburg and Freeport, it is well exposed, occurring as a coarse grained compact gray and brownish sandstone. The vegetable impressions are frequently beautiful, belonging to the genera *Sigillaria*, *Lepidodendron*, *Calamites*, &c., the first existing in great abundance. This stratum seems to have been deposited by a rather turbulent current, if we may judge from the oblique and irregular disposition of the layers. These are often separated by thin bands of shale, and sometimes by seams of coal from six inches to two feet thick, which frequently thin out in the space of ten or twenty yards. The brown variety crumbles by exposure into a ferruginous sand.—Persons in quest of coal should avoid confounding the numerous bands in this stratum, with the more regular seams of the series from which they differ in being never continuous, ending sometimes very abrubtly. Thickness seventy feet.

No. 11—*Shale.*

Between the preceding sandstone and the coal next to be described, occurs an important stratum of dark shale, containing fireclay and nodular iron ore. Some layers are soft and carbonaceous, resembling at their outcrop a coal smut; others are friable, breaking into narrow, longitudinal fragments. In some places it embraces layers of slaty sandstone, also fireclay of good quality. Near the middle of the mass are two bands of coal, requiring particular notice. The first of these is one foot thick, the other varies from one foot to eighteen inches in thickness. As we have not found these to be continuous over any great space, and as they are too thin to be profitably worked, we have not deemed it expedient to describe them as separate seams. In some localities, the laminæ of the shale are remarkably regular, and it may be procured in large plates; other portions contain much sulphuret of iron, and readily crumble by exposure. The iron ore of this stratum

is usually in slabs, irregularly scattered through the shale, but most abundant above the underlying coal.

This member of the series deserves especial attention, as it probably contains, in some situations, seams of coal worth pursuing, besides valuable deposits of iron ore and fireclay. Thickness from 75 to 100 feet.

No. 12—*Coal.*

Immediately underlying the above stratum, is a widely extended and important seam of coal, emerging from below the Allegheny river, about five miles above the mouth of the Kiskiminitas. At Kittaning it attains an elevation of six feet, being extensively wrought near the base of the hills, on both sides of the river. It is 3½ feet thick. At its outcrop the coal is often inferior, but further in the hill, it affords an excellent fuel. Like all the other seams, it varies somewhat in thickness, and contains irregular nodules of sulphuret of iron. Many of the salt wells in the vicinity are supplied with fuel from this bed.

This coal seam may be readily traced on the river hills, between Kittaning and the mouth of the Clarion river. On each side of the Allegheny, we find it heading in the small streams and brooks which empty into the river. It finally sinks beneath the water level of the country, towards the south-west, to re-appear on the Beaver river and its branches. Its position above the fossiliferous limestone, to be described presently, enables us to trace it with facility and precision. Eastward of the Allegheny river, it shows itself on the Cowanshannock creek and on Crooked creek, ranging to within a short distance of the county line of Indiana, and likewise on Red Bank Creek, where it reaches to about the same distance from the Jefferson county line. Disappearing beneath the hills which form the west slope of the Allegheny river at Kittaning, it re-appears on Buffalo creek, where it is worked at Horner's Mills. Thence it passes under the high grounds in the centre of Butler county, and reaches the day once more on the Slippery Rock and other streams, towards the west. This seam is mined on the Neshannock creek.

In consequence of the changeful thickness of the shale, interposed between this coal bed and the fossiliferous limestone beneath, it sometimes rests almost in contact with the latter, though the usual thickness of the shale is from twenty-five to thirty-five feet. Considering the great extent of country occupied by these strata, and the manner in which they were deposited, some from quiet waters, some from turbulent currents, it should not surprise us that they thus vary in thickness and composition. Their position in the series, however, is constant, and a careful examination will almost invariably enable us to trace them. Thickness of the coal, from three to five feet.

On the south side of the Red Bank creek, in Red Bank township, Armstrong county, a deposite of *cannel coal* has been opened on the lands of Mr. Alexander Cathcart. Here we find a bed of common *bituminous coal* two feet thick, supporting one of *cannel coal* eight

feet six inches in thickness. The latter is light, compact, of a dull lustre, and a conchoidal fracture, and belongs to the variety denominated slaty cannel coal. It ignates with facility, burning with a bright flame, and leaving but a moderate amount of ashes. It forms a compact bed not regularly laminated, and is distinctly separated from the coal beneath. From all the evidence we could collect, without resorting to extensive digging, we conceive this coal seam to be the same with that above described. The cannel coal is not traceable beyond this neighborhood, being merely a local modification of the deposite, the remarkably bituminous roof of the bed passing into cannel coal.

Three miles from Greensburg, Beaver county, there occurs a very analogous bed of cannel coal, resting on ordinary bituminous coal.—The whole seam there is eleven feet in thickness.

No. 13.—*Shale.*

Below the coal just described is a bed of brown and black shale, with interposed layers of sandstone. This is an important repository of nodular *iron ore*, always containing that mineral in greater or less abundance. The ore is generally greatest in amount directly under the above mentioned coal seam, where the shale is soft and friable.—In Clarion county, and the southern part of Venango, where this stratum not unfrequently caps the hills, covering the limestone to be described, we find it to contain large quantities of blue nodular iron ore. Both in Venango and Mercer counties, the centre of the stratum is sometimes occupied by a bed of solid sandstone, occasionally ten feet in thickness. It is worthy of remark, that the iron ore abounds in proportion to the deficiency of these sandstone layers in the stratum. Average thickness twenty-five feet.

No. 14.—*Buhr-Stone, and Brown Siliceous Iron Ore.*

Between the shale above spoken of, and a limestone to be next described, occurs a siliceous and ferruginous deposite of great economical importance, and of singular character. When not largely impregnated with the oxide of iron, this bed constitutes a hard greyish and yellowish chert, or flint, of a somewhat cellular structure. Some portions are precisely analogous, both in composition and appearance, to the burr-stone of France. When it is much charged with the oxide of iron, with which it is in contact, the weathered specimens exhibit a worm-eaten or cavernous appearance, arising not merely from the removal of the oxide of iron lodged in it, but from the dissolution of the calcareous matter derived from the adjacent limestone. The open cellular variety is usually white or yellowish; the compact kind black, bluish, and brown. The bed is sometimes fossiliferous, containing *encrini*, and other organic remains.

Reposing directly upon the siliceous rock and passing into it, there is a highly important bed of iron ore, which has already become

of great value to the counties bordering the Allegheny river, and which is destined to occupy a still more conspicuous place among the mineral treasures of our great bituminous coal field, when its true geological relations shall be understood, and its productiveness appreciated. This ore consists generally of a mixure of the peroxide and protocarbonate of iron, the latter predominating, except near the outcrop. At its outcrop it is composed almost exclusively of the brown hydrated peroxide, and is of various tints of brown and red. Its structrue is often cellular, the irregular cavities being surrounded by a thinner or thicker crust of the ore. In other instances, it occurs in large masses, in which the ore is intimately mingled with the chert, and is full of drusy cavities, lined with minute chrystals of quartz, tinged red, brown, and pink, by the oxide of iron. These cavities sometimes contain water. Though this seam of ore follows the limestone over considerable spaces of country, it is not strictly continuous, but occurs rather in large patches of various thickness. The buhr-stone and the iron ore would seem indeed mutually to replace each other, the one most abounding where the other is deficient. For the chemical composition of this ore, see the *analyses*, Chap. VI.

Where the fossiliferous limestone emerges from beneath the level of the Allegheny river, a few miles above the mouth of the Kiskiminitas, the ore and buhr-stone are not discoverable. They occur, however, at the furnace of Mr. M'Nichols, 2½ miles above Kittanning.—Here the ore overlies the limestone, in a band which in some places is two feet nine inches thick. The upper layers of the limestone are impregnated with more or less of the ore. This rock is of a buff color at its outcrop, effervescing freely when touched with an acid, and being full of various fossils. The buhr-stone or siliceous stratum, is found in detached beds, from six to eight yards in area, overlying the limestone. It is here a yellowish white flint.

Proceeding northward from this neighborhood, we have traced this ore in the river hills, between Red Bank and Mahoning creeks. The buhr-stone was also observed, overlying the fossiliferous limestone, at the mounth of Sugar creek, and also at the mouth of Bear creek, in the vicinity of Lawrenceburg. Eastward of the Allegheny river, the ore extends through Clarion county, the limestone rising to the surface of the country. This ferruginous bed, connected with the buhr-stone, supplies ore to Mill Creek, Webster, Beaver, Shippenville, Lucinda, Madison, and Clarion furnaces, in this county, and to Etna and Jackson furnaces, in Butler county. In Richland township, Clarion county, it is mined on the land of Mr. M'Ginnis. The ore here rests in immediate contact with the buhr-stone and limestone.—Its average thickness is fifteen inches, but in some places it is three feet. Between the ore and limestone, their often occur large cavities, some of which are several yards in extent, and from twelve to twenty inches deep. These seem to have been formed by the removal of the shale and other strata, by the gradual infiltration of the water from above. The overlying shale both here and in many other localities,

has been converted into a tough clay, in which the lumps of siliceous ore are imbedded.

The ore has been opened on the land of Mr. John Allsbach, in this neighborhood. The bed is there nine inches in thickness, and is partially interstratified with the flint, which occasionally renders it too siliceous to be profitably smelted. The rock breaks into large cuboidal masses of a grey, blue and yellow color, having spots and little seams of brown iron ore. These masses are occasionally much weather-eaten from the disintegration of the calcareous and softer portions. The overlying bed of ore varies from nine to eighteen inches in thickness.

About two miles south of Shippenville, the ore is mined at the "deal bank," belonging to Messrs. Shippen and Black, and to Myers & Co. The thickness of the ore averages two feet. It is a compact stratum, overlaid by blue shale and slaty sandstone. It is opened on the land of Blackstone, Long & Co., in the same neighborhood where it has a similar structure, though its thickness is unusually great. It here occurs in a solid bed about five feet in thickness, in one place becoming nine feet thick. It has an imperfectly cellular structure, and contains drusy cavities, some of which are filled with water. The material of the buhr-stone mingles itself in small quantities with the ore, and indeed the whole deposit is remarkably siliceous.

In Elk township, about a mile and a-half south of the turnpike, the ore is exposed on the lands of William Allsbach, Joseph Kutcher and others. At Kutcher's bank the bed varies from one to two and a-half feet in thickness. It is here chiefly of the spathose variety, being a semi-crystalline protocarbonate, of a grey and somewhat metallic aspect, and very heavy and compact. It breaks into large masses, consisting of the protocarbonate, surrounded by a crust of the peroxide, of a deep red color, which is usually an inch or more in thickness. One mile north of this locality, the limestone crops out on the surface of the ground, exhibiting itself in white and yellowish masses generally two or three feet in length.

The buhr-stone ore is wrought at Lucinda furnace, about *eight miles* north of Shippenville, and also in Pinegrove township, on the land of Mr. Henly, and others. At the former place it overlies the limestone, and varies in thickness from six to twenty-four inches. In some places the ore is replaced by the flint or buhr-stone. Much of it is of the cellular variety, the drusy cavities being often coated with a beautiful glaze, such as we behold in the hollow balls of ore found above the limestone, F. II. in the valleys of the Appalachian region of the State.

On the western side of the Clarion, in Paint creek township, the ore and buhr-stone are well exposed on the lands of Samuel Thomas, Daniel M'Naughton, and others. In the country south-east of that stream, the ore is exposed in many localities, and can be traced to the Jefferson county line. Its eastern and northern outcrop is governed by that of the limestone which it accompanies. Following it to the south-west we find it, after it passes under the river hill at Kittanning

reappearing on Buffalo creek, and there burying itself beneath the high grounds in the central parts of Butler county, to emerge again in Muddy creek, Slippery Rock, and Mercer townships. It is opened on the land of Judge Bouvard, four miles east of Centreville, where the bed is from six to twenty inces thick, the buhr-stone occasionally replacing the ore, and forming a bed which is here sometimes one foot thick, resting upon the limestone. The ore is wrought on the land of Mr. Buchanan, about two miles north of the above locality, where it and the buhr-stone are seen overlying the limestone. The ore is of excellent quality, and averages nine inches in thickness.

The great importance of this valuable deposit to the growing wealth and enterprise of the western part of the State, is beginning to be appreciated. I need hardly, therefore, dwell upon it any further than to mention the following circumstances in its favor. The richness of this ore, far exceeding that of the nodular variety common in the slates of the coal measures, will bear comparison with much of the best ore found in the limestone valleys south-east of the Allegheny mountain. Another merit is the facility with which it may be smelted either alone or when mixed with the nodular or ball ore, and particularly with the bog ore found so abundantly in Venango and Clarion counties. In the thicker parts of the deposit, it is a nearly pure semi-crystalline protocarbonate of iron, a variety well known to be susceptible of extremely easy reduction. It is moreover recommended by the readiness with which it can be traced, arising from its accompanying closely the fossiliferous limestone, which furnishes an excellent land-mark. The buhr-stone assists the discovery of it in a still greater degree, the fragments of that peculiar stone being so easily recognized, serving to point out the position of the ore. Besides these important facts, it should be mentioned that a workable seam of coal occurs above the ore and limestone, and another beneath them at a moderate interval. The importance of this tripple association of the materials employed in the manufacture of iron, to the future wealth of our western counties must be obvious to every one who adverts to the incalculable advantage which Great Britain has derived from the same fortunate union.

No. 15.—*Fossiliferous Limestone.*

The stratum which next succeeds the buhr-stone in the descending order, is a compact bed of light blue limestone. Its upper layers are occasionally tinged yellow by the ferruginous infiltration from the overlying stratum. In other instances, the weathered surfaces are of a dark grey color. The limestone in certain localities is remarkably slaty, consisting of thin shivery layers. This peculiar aspect arises in part from its sandy composition, which impairs its cohesion. When it is of this kind, much care is requisite in converting it into lime, lest too intense a heat should vitrify it. Properly calcined it yields an excellent gray lime. It abounds in fossils, particularly of the genus *encrinite*, the round seams of which stand out from the weathered

surfaces of the rock. They are generally composed of crystalized rhombic carbonate of lime; and the characteristic fossil is a small species of *terebratula*, which in some places seems to constitute a large proportion of the rock. The teeth and other remains of *sancoid fishes* also exist in this stratum.

The limestone rises above the level of the Allegheny river, about four miles above the mouth of the Kiskiminitas. At this latter place it has been passed at the depth of one hundred feet in boring a salt well. At Kittanning it attains an elevation of one hundred and four feet above the river, being here ten feet in thickness. East of the river it is exposed along many of the tributary streams, particularly Crooked creek, where it measures seven feet in thickness. We find it on Red Bank creek, east of the village of New Bethlehem, and also well exposed on the land of Mr. Joseph Smith, where it lies near the water, in a bed ten feet thick. It re-appears west of Kittanning on Buffalo creek, and on Rough river, forming a conspicuous stratum fifteen feet in thickness.

Gradually rising as we advance up the Allegheny river, the limestone shows itself on the hills of Sugar creek, and is seen at the mouth of Bear creek at a height of several hundred feet above the water, capping the summits. From this point it stretches to the north-east, being traceable on both sides of Clarion river, until it reaches the western line of Jefferson county, beyond which we have not yet pursued it. Some striking and peculiar features mark the northern outcrop of this limestone, especially near the line of the northern turnpike. Rising with a gentle elevation from the south-west, it forms a series of insulated knobs, usually covered with a growth of chestnut and other deciduous trees, which contrast strongly with the surrounding evergreen foliage of the pine and hemlock. The position of the limestone in these knobs is plainly indicated, even to the eye of a superficial observer, by a little bench or terrace, caused by the washing away of the soft and underlying strata. These limestone knobs are numerous in Pine Grove, Elk Creek and Irvine townships, in Venango county. On the western side of the Allegheny river, the northern outcrop of the stratum is still more distinctly defined. It approaches within ten miles of Franklin, where it is exposed on the farm of Mr. Boner. It shows itself on Sugar creek, Bear creek and Buffalo creek, at a small elevation above these streams, westward of which it disappears under the hills of Butler county, coming again to the surface on Muddy creek and Slippery Rock. Near the former stream it may be seen on the lands of Mr. Jonathan Wriner, where it is accompanied by the buhr-stone, and is fifteen feet in thickness.

Slippery Rock and Mercer townships, in Butler county, being much lower than the township south of them, present a surface formed of this limestone and the strata which immediately overlie it. The bed is wrought in the neighborhood of Centreville and Harrisville, where it forms a series of low, flat ridges, similar in outline and structure to the hills which mark its outcrop in Clarion county. Rising gradually from the north-west corner of Butler county, it extends to the centre

of Mercer, its northern outcrop being traceable from the vicinity of Sandy lake, in a south-west direction, passing west of the town of Mercer, and thence onward until it reaches the State of Ohio.

This bed of limestone is exposed on the land of Mr. Porter, one mile from the town of Mercer, where it is between two and three feet thick, and rests directly in contact with an underlying seam of coal, which in other places is usually separated from it by a bed of shale. This locality is near the north-western limit of the stratum, which seems to thin out and disappear as we follow it towards the north-west. The rock is here slaty in its upper layers, and darker and heavier than usual. It has this same aspect at Sandy lake, ten miles N. N. E. of Mercer, on the margin of which the limestone is exposed in a dark and slaty seam, only fifteen inches thick, having a bituminous odor and abounding in fossils. It is overlaid by two seams of coal which have been opened. The upper one is five feet in thickness.

Three miles above New Castle, the limestone is exposed on the farms of Mr. Carpenter and others, where it occurs at a considerable elevation above the Neshannock. It is here a dark blue, very compact and fossiliferous rock, about ten feet in thickness. The stratum is again visible on the hills which overlook the Beaver river, about nine miles below New Castle, where it is ten feet in thickness, and has the singular shrivelled aspect which it present on Crooked creek, in Armstrong county. It is also exposed at various other places in this vicinity. Descending the Beaver we may trace it finally to the Ohio river, where it is well exposed two miles below the borough of Beaver, in the form of a dark blue, fossiliferous stratum, twenty feet thick, which dips gently to the south-west. It here occurs at the base of the hills at a small elevation above the river, beneath which it finally disappears.

The wide range of this stratum, its value as a source of pure lime, and its importance as a guide to the overlying buhr-stone ore, are too obvious to require comment here. Its exact position may be readily ascertained by the inhabitants of the wide district over-which it spreads, in almost every spot where it lies above the general water level of the country. It is only necessary to attend to the dimension or thickness of the strata here laid down, to identify some well characterized member of the series, and then to institute a simple measurement by a levelling instrument, giving the heighth or depth of the ascertained stratum, and we can infer with sufficient accuracy the situation at any place, both of this limestone and every other bed in the group. There are numberless points on both sides of the ravines, where the outcrop of the limestone is concealed by a slight covering of earth, where it could readily be detected if the farmer had a correct notion, such as the present report is intended to convey, of the true relative position of the strata, and their general range and dip. A little knowledge respecting the true place in the series of this limestone, will prove an invaluable guide to the coal, several seams of

which occur near it, in situations readily ascertained by calculation from the thickness here furnished. The average thickness of the limestone may be stated at fifteen feet.

No. 16. *Shale.*

Beneath the limestone rests a bed of shale of great importance, in an economical point of view, as it is the depository of a considerable amount of nodular *iron ore.* It has the usual aspect of the shale of the coal measures, and like nearly all of them, is occasionally replaced by layers of argillaceous sandstone. In such cases, the stratum acquires twice its usual thickness, becoming a mass of alternating layers of shale and slaty sandstone, separating the limestone from the underlying seam of coal. Tracing it in connection with the other members of the series, we find it well exposed at Allegheny *furnace,* two and a-half miles above Kittanning. It here embraces nine layers of nodules of the ore, in a thickness of twelve feet. These nodules vary in diameter from six to twelve inches. They are flattish, and of a lemellar structure. Ore of good quality occurs in this shale at various other places in the same section of country.

Ascending the Allegheny river, we meet with many localities where this stratum presents indications of the ore. Near Scrubgrass and Rockland furnaces, the ore is extensively worked. This shale merits indeed an attentive examination on the part of those interested in the development of iron ore. In many places the rock is between thirty and forty feet thick, when it contains much slaty sandstone. In the southern part of Venango county, especially in Irwine and Rockland townships, it does not exceed ten feet. The lower layers in contact with the coal, often contain vegetable impressions. The average thickness of the mass is twenty feet.

No. 17. *Coal.*

Underlying the preceding stratum, there occurs a *vein of coal* extending over a considerable tract of country. We find it slowly rising above the base of the river hills, above Kittanning, until it attains an elevation of several hundred feet near the mouth of Bear creek. It has been here mined to a small extent on the land of Mr. R. Leonard, the seam being three and a-half feet thick, and affording an excellent coal for fuel; under it there lies a bed of fire-clay, three feet in thickness. At Robinson's salt wells, eight miles lower down the Allegheny, this coal seam is worked to the height of two hundred and thirty-three feet above the river. East of the Allegheny and south of the Clarion, it is opened in many places. At the mouth of Schull's run, it crops out along the brow of the river hills at a still goater elevation than that above recorded. On the opposite side of the Allegheny, it is well exposed on the lands of Mr. Crawford and others. There is a seam of coal five feet in thickness opened in this neighborhood, on the lands of Mr. Coe and others, which, as far as we have

yet been able to determine, is the same bed as that now described. Over it lie three thinner layers of coal, each less than a foot in thickness, separated from each other by shale.

The coal bed we have been tracing, ranges through Irwine and Sandy creek townships, Venango county, where it is worked on the lands of Messrs. Wm. Cross, Joseph M'Kean ——— Boner and others. It here lies about twelve feet below the limestone. Rejecting a band of coal twenty inches thick, embraced in the overlying shale, the principal seam measures three and a-half feet in thickness. It can be traced east of the river throughout Venango and Clarion counties, as far as the boundary line of the latter, beyond which no examination has yet been made. It is well exposed in many places in Pine Grove and Farmington townships, as at Lucinda furnace, where it occurs about thirty feet below the limestone.

This seam of coal, in common with many other members of the series, appear to thin away towards the north-west as it approaches its outcrop, for in the vicinity of the town of Mercer we find it lying immediately below the limestone, and only three feet thick. At the north of Beaver river, there occurs a bed of coal near the level of the Ohio, the position of which, in relation to the overlying fossiliferous limestone, is identical with that of the present seam. Traced to the south-west, it sinks beneath the bed of the Ohio, in conformity with the general dip of all the coal measures in this neighborhood. The average thickness of this coal seam is four feet.

No. 18—*Shale and Argillaceous Sandstone.*

Immediately under the coal just described we find a bed of shale, sometimes passing gradually into a slaty argillaceous sandstone. The upper layers near the base of the coal frequently contain nodules of *iron ore*, which are sometimes from two to three feet in length, and of excellent quality. These seem to lie irregularly in the shale; the smaller nodules are more homogeneous in composition, compact and fine grained. Sometimes, however, they contain much sulphuret of iron and calcareous spar. The larger masses include generally an oblong somewhat cylindrical nucleus, which near the outcrop is surrounded by a concentric crust of peroxide of iron, of various degrees of fineness. This outer shell readily crumbles by exposure. Closely examined, these large nodules present a distinctly oolitic structure. Though of a coarse grain, derived from a large amount of earthy ingredients, they are freer from sulphur than the smaller and more compact nodules. The shale in which the ore most abounds, is of a yellow color, soft and friable, and belongs to the first eight feet below the coal.

In the lower layers of the general stratum, we sometimes find thin bands of coal and black bituminous shale, varying from three to ten inches in thickness. Care should be observed not to confound these with the regular continuous coal seams which we have enumerated as separate members of the series. Good iron ore is obtained from

the present stratum, in the vicinity of Rockland furnace, in Rockland township, Venango county.

When the sandstone layers increase in quantity and thickness, the iron ore becomes proportionately deficient. Separating the layers of sandstone, occur sometimes bands of soft bituminous shale, which resemble coal smut, and which frequently mislead the explorer after coal. The upper half of the stratum passes by decomposition into a bed of clay, showing but few traces of the original lamination of the shale. This contains some nodules of iron ore. The average thickness of the whole stratum is about forty feet.

No. 19. *Coal.*

Succeeding the above deposit of shale and sandstone, there occurs another seam of coal which we have traced over a considerable range of country. As its outcrop extends in a north-east and south-west direction through Mercer, Venango and Clarion counties, traversing a country where the rocks are much concealed by forest, we find the bed but very partially exposed. Its position, at a moderate depth below the limestone, greatly facilitates its detection. It will prove a valuabled bed whenever the district which it occupies shall become thickly settled. It is the lowest workable coal seam hitherto found in the series along the Allegheny river, for, though numerous thin bands of coal occur in the slate beneath it, we have yet found more of them of sufficient size to merit a distinct enumeration. This layer of coal is opened on the farm of Mr. Joseph Brandon, six miles east of Franklin, where it lies on the summits of the hills beneath the black bituminous shale. It here measures twenty inches in thickness, and is a kind of semi-cannel coal, light, of a slaty structure, and of a peculiar lustre. It somewhat resembles a soft black slate, but is a tolerably pure coal, burning freely, with considerable flame.

It is opened on the lands of Messrs. John W. How and E. Bratton in Rockland township, where it occupies the river hills. Here the layers succeed each other as follows:

Brown shale with ore, ...	8 feet
Coal, ...	4 inches.
Black shale, ...	1 "
Coal, ...	3 "
Black shale, ...	3 "
Coal, ...	18 "

The coal ignates readily, and resembles that above described. It lies several hundred feet above the river. This seam may be traced on the opposite side of the Allegheny, in Irwine township, Venango county, being opened on the land of Judge M'Kee, where it is about two feet in thickness, and rests on the bituminous shale. Thickness two feet.

Formation XII. *White Sandstone*

We have now arrived at the coarse and massive sandstone which constitutes the bottom of the productive coal measures, and which exercises a marked influence in the topography of the country.—Emerging from the level of the Allegheny river, above Kittanning, this stratum rises to a considerable height above the water, near the mouth of the Clarion, though it is covered by the overlying coal measures. In the neighborhood of Franklin, however, it caps the hills on both sides of the river, and forms the general surface of the country throughout the northern part of Venango.

In this section of the State, F. XII. is of a fine grained sandstone, consisting of minute rounded grains of quartz. Its prevailing color is a whitish gray, though it is often streaked and blotched with brown peroxide of iron. Where it is much exposed to the weather, it disintegrates into sand, the ferruginous matter being removed by solution. The whole mass consists usually of two solid beds of sandstone, the upper about fifteen feet, the lower about thirty feet in thickness. These are separated by layers of shale and slaty sandstone, variously alternating, which contain a considerable quantity of nodular iron ore. It is this formation, which, rising gradually from the south, forms the surface of those extensive glades or high barren planes, so common along the northern margin of the coal region. These glades are generally covered with a sparse and stunted growth of wood or other vegetation, sustained by a thin and sandy soil, which predominates, except where certain basin-shaped depressions of the surface have received the argillaceous matter derived from the shales. The sandstone may be readily discovered either rising in massive beds from beneath the soil, or forming thick ledges along the sides of the ravines and vallies. Though these rocks injure the agricultural character of this district, they are not without their merits, furnishing an admirable building stone, well suited for the construction of furnaces. The best variety of the sandstone for the in-walls of furnaces, is the soft and light gray kind, marked by minute circular blotches, of a brown or black color, imparting a variegated appearance to the rock. This is easily dressed, and resists the fire remarkably well.

Throughout the district in which this rock prevails, we find numerous and valuable deposits of *bog iron ore*. This material is generally precipitated from the waters of Chalybeate springs, which issue along the sides of the ravines, bringing with them the ferruginous particles of the sandstone and the pyritous shales in contact with it.

The extreme margin or outcrop towards the north, has not been accurately traced, except along the Allegheny river. It has been pursued to the north of Teonista creek, where we recognize a well marked stratum, belonging apparently to the bottom of the formation. This is a solid bed of fine grained gray and brownish sandstone, eight feet in thickness. It occurs at the height of fifty feet above the creek, and has the aspect in some places of a true conglomerate, some of its layers imbedding numerous rounded pebbles of white quartz. North

of the Teonista, a sandstone, supposed to belong to the same formation, is extensively met with, but the wilderness condition of the country there, has hitherto prevented its being minutely examined.— It is a white sandstone, in some places assuming the features of a conglomerate. On the opposite side, two miles south of the Tytiute creek, a coarse conglomerate is to be seen lying near the summits of the hills. This is traceable to the town of Warren, and is undoubtedly the principal member of F. XII., as it is developed in this part of the country. Ascending French creek, we find this stratum constituting the summits of the hills until we arrive at Meadville. West of the Allegheny river, the rock is extensively developed, being exposed along the Shenango river from Greenville to Sharon and New Castle, affording in many places a superior building stone for the construction of locks, bridges, &c., on the public works. The exact range of this formation will be ascertained during the approaching season. Its average thickness is about one hundred feet.

Rocks below Formation XII.

Beneath the rocks above described, we find on the Allegheny river and its tributaries, a series of well defined strata, consisting of shales and thinly bedded argillaceous sandstones, variously interstratified. The thin arenaceous layers are generally from two to ten inches thick, light blue, fine grained and micaceous, and splitting into neat flags. Other layers contain vegetable impressions, beautiful specimens of which, especially of the *genus fucoides*, abound in this rock. Many of these thin flaggy sandstones exhibit "ripple marks," possessing great breadth and regularity of form. The shales are generally dark colored and soft, and contain thin seams of *iron ore*, identical with that of the coal measures. Thin beds of impure coal have likewise been met with in the upper layers, but no workable stratum is known.

The rocks here mentioned, compose the river hills in the neighborhood of Franklin, where they underlie the thick sandstone above described. They are well exposed along most of the streams of the northern half of Venango county. We have traced them also up the Allegheny river to the mouth of Teonista creek, and up French creek as far as Meadville. On the Shenango and the neighboring streams, they are again met with. The arenaceous limestone described in my last annual report, as a bed two feet in thickness, is a member of this series, and retains its characteristic features over a great range of country, with remarkable constancy,

Our investigations during the past year, not being particularly directed to the country occupied by these lower rocks, it is useless to attempt, at present, a more detailed description. They will be discussed minutely in a subsequent publication.

CHAPTER VI.

Composition of the Iron Ores referred to in this Report.

For the purpose of comparison, and for the sake of convenient reference, I have deemed it best to assemble under one chapter, the various analyses of iron ores referred to in the body of this report, adding some others not specifically alluded to, which belong to formations and localities described in my former annual publications. It will be seen from the list here presented, that this State is remarkable, no less for the singular variety of its iron ores, than for the extraordinary abundance in which some of these prevail. The limited scope of an annual report, and the necessity for more time to comple various branches of research, relating to our ores and the kinds of iron which they are generally best adapted to produce, compel me to defer entering for the present, upon a number of highly useful practical topics suggested by the analytical details here introduced. In the mean while, however, it will interest those who are in any manner connected with the developement of working of our ores, to find the exact composition and relative richness and purity of a large number of them thus displayed.

It will contribute to clearness of arrangement, and at the same time meterially assist us hereafter in arriving at useful general laws, concerning the intimate connections which subsist between the geological situation of these ores and their chemical nature, if we classify their analyses here given, according to the formations in which the ores are found. I shall commence, however, with the specimens derived from the primary rocks, and then present those of the various secondary formations, following the ascending order.

Section. I.

Analyses of Iron Ores from the primary rocks of the south-eastern district of the State.

Titaniferous Iron Ore from near Isabella Furnace, on the East Branch of Brandywine creek, Chester county. This ore occurs as a vein in gneiss rock.

DESCRIPTION.

The specimen is of a black color; lustre metallic; cleavage foliated, sometimes granular; has magnetic polarity.

Specific gravity, 4.95

COMPOSITION IN 100 PARTS:

Titanic acid,	22.39
Protoxide of iron,	76.86
Loss,	.75
	100.00

This specimen contains 59.44 per cent. metallic iron.

IRON ORE from the Yellow Springs, Chester County.

DESCRIPTION.

The specimen exhibits the usual appearance of brown *hematitic* iron ore, but has a resinous lustre. It occurs in a ferruginous loam, overlying the gneiss.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	82.91
Alumina,	1.35
Water,	13.90
Silica and insoluble matter,	3.32
	101.48

The proportion of metallic iron in this specimen is 57.55 per cent.

SECTION II.

Analyses of Iron Ores of Formation I.

IRON ORE from Chesnut Hill, near Columbia, Lancaster County.

DESCRIPTION.

Brown; compact; surface mammillary; outer portions of the mass crystalline and radiated. The analysis was performed upon a piece representing the average of the mass.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	84.39
Alumina,	2.46
Silica and insoluble matter,	2.38
Water,	10.99
	100.22

The metallic iron amounts to 58.51 per cent.

IRON ORE from Susan Ann Furnace, York County

DESCRIPTION.

Blackish brown; micaceous, and sandy.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	40.71
Peroxide of manganese,	8.91
Alumina, (phosphate),	2.84
Insoluble matter, including phosphoric acid,	39.56
Water,	7.98
	100.00

This specimen contains 28.23 per cent. metallic iron.

IRON ORE from M. G. Ege's Mountain Bank, South of Carlisle Iron Works, Cumberland County.

DESCRIPTION.

Amorphous; color, dull bluish-brown; powder, brown; texture, friable; aspect, earthy.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	20.10
Alumina,	0.10
Peroxide of iron,	49.80
Peroxide of manganese,	17.55
Water,	12.00
Loss,	0.45
	100.00

This specimen contains 33.86 per cent. metallic iron.

IRON ORE from a Bank half a mile from Carlise Iron Works, M. G. Ege's.

DESCRIPTION.

Dull black color; lustre somewhat metallic; sub-crystalline; slightly magnetic: has some resemblance to the ores of the Warwick and other mines adjacent to trap dykes.

COMPOSITION IN 100 PARTS:

Magnetic oxide of iron,	64.79
Peroxide of iron,	27.93
Oxide of Manganese,	a trace
Alumina,	a trace
Silica and insoluble matter,	3.30
Water,	3.81
	99.83

This ore contains 65.88 per cent. metallic iron.

IRON ORE from the Mountain Ore Bank of Carlisle Iron Works.

DESCRIPTION.

Brown; mottled; somewhat cellular; locally called "honey-comb ore."

COMPOSITION IN 100 PARTS:

Peroxide of iron,	70.04
Peroxide of manganese,	3.32
Alumina,	a trace
Silica and insoluble matter,	16.32
Water,	10.96
	100.64

This specimen contains 48.56 per cent. metallic iron.

IRON ORE from General T. C. Miller's Mountain Bank, Cumberland Furnace, Cumberland county.

DESCRIPTION.

Brown hemetite; botryoidal on the surface, and somewhat porous; color of mass orchrey.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	12.0
Alumina,	0.4
Peroxide of iron,	74.8
Water,	12.0
Loss,	0.8
	100.0

This specimen contains 52·36 per cent. metallic iron.

IRON ORE from Peffer's Bank, six miles south-west of Carlisle, Cumberland county

DESCRIPTION.

Amorphus, compact; color dark brown; interspersed with light colored ocherous matter.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	12.1
Alumina,	4.3
Peroxide of iron,	69,4
Water,	14.0
Loss,	0.2
	100.0

This specimen contains 48.58 per cent. metallic iron.

IRON ORE one mile and three-fourths from Carlisle Iron Works, Cumberland county.

DESCRIPTION.

Pipe ore; pipes small; color dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.05
Alumina,	a trace
Peroxide of iron,	85.65
Water,	8.80
Loss,	0.90
	100.00

This specimen contains 59.95 per cent. metallic iron.

IRON ORE from Pond Bank, used at Caladonia Furnace, Stevens and Paxton's, Franklin county.

DESCRIPTION.

Hematitic; imperfectly crystallized; form rounded; color dark chesnut brown. Specimen consists of a fragrant of a hollow spherical ball.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	9.30
Alumina	trace
Peroxide of iron.	79.05
Water	12.00
	100.35

This specimen contains 55.33 per cent. metallic iron.

IRON ORE from the Hill Bank used at Southampton Furnace, Franklin county, (better portion.)

DESCRIPTION.

Texture cellular; surface of cells sometimes lined with crystalized hematite; color dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.90
Alumina,	2.70
Peroxide of iron,	78.85
Maaganese,	trace
Water,	12.50
Loss,	0.05
	100.00

This specimen contains 55.19 per cent metallic iron.

IRON ORE from the Hill Bank, used at Southampton Furnace, Franklin county, (inferior portion.)

DESCRIPTION.

Amorphous, cellular, dark brown alternating with light colored matter.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.80
Alumina,	1.80
Peroxide of iron,	76.30
Manganese,	1.00
Water,	14.50
Loss,	0.60
	100.00

This specimen contains 53.41 per cent. metallic iron.

IRON ORE from Montalto Furnace, Hughes' Franklin county, (Lower Ore.)

DESCRIPTION.

Texture cellular; color, dark chesnut brown; walls of cells compact, interior occupied by light colored ochreous matter.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	7.0
Alumina,	3.3
Peroxide iron,	75.2
Water,	14.0
Loss,	0.5
	100.0

This specimen contains 52.64 per cent. metallic iron.

IRON ORE from Montalto Furnace, Franklin county, (Upper Ore.)

DESCRIPTION.

Mottled brown and ochrey; in some parts compact; in others soft and cellular, and distinctly laminated.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	13.3
Alumina,	2.5
Peroxide of iron,	71.0
Water,	12.6
Loss,	0.6
	100.0

This specimen contains 49.70 per cent. metallic iron.

IRON ORE from a Bank one mile southwest from Hughes' Forge, Franklin county.

DESCRIPTION.

Texture, compact; massive; color, dark brown; aspect of fresh surface somewhat resinous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.80
Alumina,	1.40
Peroxide of iron,	79.10
Sesqui oxide of manganese,	4.00
Water,	12.00
Loss,	0.70
	100.00

This specimen contains 55.37 per cent. metallic iron.

IRON ORE use at Pond Furnace, (Moore's,) Franklin County.

DESCRIPTION.

Impure hydrated oxide; texture, hœmatitic; semi-crystalline on surface, which is covered with mammillary protuberances; color of mass, brownish yellow—of surface, dark brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter, ...	10.0
Alumina, ...	2.6
Peroxide of iron, ...	73.5
Manganese, ...	a trace
Water, ...	13.0
	99.1

This specimen contains 51.35 per cent. metallic iron.

SECTION III.

Analyses of the Iron Ores of the Limestone Formation II.

IRON ORE from Miller's Mine, four miles North-West of Allentown, West side of the Lehigh River, Lehigh County.

DESCRIPTION.

Brown; stalactitic; variety, "pipe ore;" the cavities partly filled with pulverulent yellow oxide of iron.

COMPOSITION IN 100 PARTS:

Peroxide of iron, ...	86.59
Alumina, ...	a trace
Silica and insoluble matter, ...	3.08
Water, ...	11.31
	100.98

This specimen contains 60.04 per cent. metallic iron.

IRON ORE from Balliat's Mine, five miles North-West of Allentown, Lehigh County.

DESCRIPTION.

Color, liver brown; compact; superficial portion crystalline, radiated, and mammillary. The latter part was selected for analysis.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	83.22
Alumina,	0.21
Silica and insoluble matter,	4.81
Water,	12.40
	100.64

This specimen contains 57.61 per cent. metallic iron.

IRON ORE from Balliat's Mine, five miles North-West of Allentown, Lehigh County.

DESCRIPTION.

Color, reddish brown; structure, lamellar; compact.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	84.00
Alumina,	1.00
Silica and insoluble matter,	6.50
Water,	9,50
	101.00

This specimen contains 58.24 per cent. metallic iron.

IRON ORE from Daniel Shwartz's Mine, half a-mile South-West of Emaus, Lehigh County.

DESCRIPTION.

Dark brown; compact; lustre somewhat metallic.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	79.64
Alumina,	a trace
Silica and insoluble matter,	9.05
Water,	11.40
	100 09

This specimen contains 55.22 per cent. metallic iron.

IRON ORE from a Bank, one mile West of Trexlerstown, Lehigh County.

DESCRIPTION.

Brown; compact; stalactitic; of the structure usually termed "pipe ore."

COMPOSITION IN 100 PARTS:

Peroxide of iron,	87.12
Alumina,	0.40
Silica and insoluble matter,	2.30
Sulphur,	a trace
Water,	10.90
	100.72

This specimen countains 61.03 per cent. metallic iron.

IRON ORE from the Moselem Mine, near Eskhard's Mill, four miles South-West of Kutztown, Berks County.

DESCRIPTION.

Dark, dull brown; compact.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	77.20
Alumina,	2.60
Silica and insoluble matter,	8.90
Water,	11.00
	99.70

This specimen affords 53.53 per cent. metallic iron.

IRON ORE from Gorgas's Bank, three and a-half miles South-West from Harrisburg,—Cumberland County.

DESCRIPTION.

Structure, hematitic; geodiferous; internal surface of goedes covered with a light brown incrustation; color of mass, dark brown.

COMPOSITION in 100 PARTS:

Silica and insoluble matter,	4.80
Alumina,	2.72
Peroxide of iron,	77.20
Manganese,	a trace
Water,	15.15
Loss,	0.13
	100.00

This specimen contains 54.04 per cent. metallic iron.

IRON ORE from Kerr's Fields, eight miles west from Carlisle.

DESCRIPTION.

Structure tending to laminated; color, dark chesnut brown; compact.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	13.0
Alumina,	4.8
Peroxide of iron,	69.0
Water,	13.0
Loss,	0.2
	100.0

This specimen contains 48.03 per cent. metallic iron.

IRON ORE used at Cumberland Furnace, Gen. T. C. Miller's, occurs one and a half miles from Furnace, in Limestone—Cumberland county.

DESCRIPTION.

Structure, slender pipes; color, chesnut brown; compact.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	3,89
Alumina,	2.50
Peroxide of iron,	84.60
Lime,	a trace
Water,	8,70
Loss,	0.31
	100.00

This specimen contains 59.22 per cent. metallic iron.

IRON ORE from the Helm Bank, used in Mary Ann Furnace; Whitehill and Ellis's, Cumberland county.

DESCRIPTION.

Structure, somewhat cellular; surface covered with small mammillary protuberances.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.8
Alumina,	2.0
Peroxide iron,	77.2
Water,	14.5
Loss,	0.5
	100.00

This specimen contains 54.04 per cent. metallic iron.

IRON ORE from the Clippinger Bank, used at the Mary Ann Furnace, Cumberland county.

DESCRIPTION.

Structure, large columnar; pipes, stalactitic; compact in centre; on surface, cellular; color, bright chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.60
Alumina,	50
Peroxide iron,	87.09
Water,	8.81
Loss,	1.00
	100.00

This specimen contains 60.96 per cent. metallic iron.

IRON ORE from the Clippinger Bank, used at the Mary Ann Furnace, Cumberland county.

DESCRIPTION.

Structure, numerous pipes closely cemented together; color, rich chesnut brown, with a slightly blue tinge.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.9
Alumina,	6
Peroxide iron,	84.6
Manganese,	a trace.
Water,	8.95
Loss,	0.95
	100.00

This specimen contains 59:02 per cent. of metallic iron.

IRON ORE from the Kressler Bank, used in Southampton Furnace, Franklin county.

DESCRIPTION.

Amorphous, cellular, somewhat laminated; color brown mottled.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	9.0
Alumina,	2.9
Peroxide of iron,	75.0
Manganese,	a trace
Water,	13.0
Loss,	0.1
	100.0

This specimen contains 52.5 per cent. metallic iron.

IRON ORE from the Rail road Bank used at the Southampton Furnace, Franklin County.

DESCRIPTION.

Structure cellular; color brown: compact.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	14.7
Alumina,	0.8
Peroxide of iron,	72.0
Manganese,	a trace
Water,	12.0
Loss,	0.5
	100.0

This specimen contains 50.4 per cent. metallic iron.

IRON ORE from the old diggings at Pilgrim Bank, north-east from Shippensburg.

DESCRIPTION.

Structure closely adhering pipes so as to be almost obliterated; color dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	14.0
Alumina,	0.5
Peroxide iron,	72.6
Manganese,	a trace.
Water,	12.5
Loss,	0.4
	100.0

This specimen contains 50.82 per cent. metallic iron.

IRON ORE from M'Dowell's Bank, five miles north-east from Mercersburg, Franklin county, (called garlic ore.)

DESCRIPTION.

Amorphous; cellular; color, bright brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.80
Alumina,	1.50
Peroxide of iron,	83.60
Manganese,	a trace.
Arsenic,	a trace.
Water,	9.40
Loss,	0.70
	100.00

This specimen contains 58.82 per cent. of metallic iron, and possesses a trace of arsenic.

IRON ORE from Carrick Furnace, Path Valley, Franklin county.

DESCRIPTION.

Structure, nodular; surface, mammillary; with interspersed argillaceous specks.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	17.40
Alumina,	5.80
Peroxide of iron,	59.50
Peroxide of manganese,	8.30
Water,	8.80
Loss,	0.20
	100.00

This specimen contains 41.65 per cent. metallic iron.

IRON ORE from Carrick Furnace, Path Valley, Franklin county.

DESCRIPTION.

Structure, cellular; interior of the cells coated with a buff colored ochreous deposit; color, dark chesnut brown; called "honey-comb ore."

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	3.80
Alumina,	2.25
Peroxide of iron,	84.30
Water,	8.85
Loss,	0.80
	100.00

This specimen contains 59.01 per cent. metallic iron.

IRON ORE from the Bull Bank of Pennsylvania Furnace, Centre county.

DESCRIPTION.

Hematitic; somewhat mottled; compact; fracture, conchoidal; color, chocolate brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.30
Alumina,	a trace
Peroxide of iron,	86.40
Manganese,	a trace
Water,	11.00
Loss,	0.30
	100.00

This specimen contains 60.48 per cent. metallic iron.

IRON ORE from Old Pennsylvania Furnace Bank, Centre county.

DESCRIPTION.

Pipe ore; the pipes small and closely set; color a dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.3
Alumina,	a trace
Peroxide of iron,	82.2
Oxide of manganese,	a trace
Water,	12.0
Loss,	0.5
	100.00

This specimen contains 57.54 per cent. metallic iron.

IRON ORE from the Pennington Bank, two and a-half miles South-West of Warrior Mark town, Huntingdon county.

DESCRIPTION.

Hematitic; cellular and slightly columnar; color, rich chesnut brown; surface of fresh fracture of a velvet-like lustre.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	8.8
Alumina,	0,5
Peroxide of iron,	75.2
Manganese,	a trace
Lime,	a trace
Water,	15.0
Loss,	0.5
	100.0

This specimen contains 52.64 per cent. metallic iron.

IRON ORE from Springfield Furnace Ore Bank, Morrison Cove, Huntingdon county.

DESCRIPTION.

Structure, cellular; interior of cells coated with blue-black incrustation; color, dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.8
Alumina,	0.8
Peroxide of iron,	79.6
Sesqui-oxide of manganese,	3.0
Lime,	a trace
Water,	12.0
Loss,	0.3
	100.0

This specimen contains 55.72 per cent. metallic iron.

IRON ORE from Bomb-Shell Bank, of Rebecca Furnace, Morrison Cove, Huntingdon county.

DESCRIPTION.

A section of hollow geode or bomb, hematitic fibours crystaline, inner surface botryoidal, and iridescent.

COMPOSITION IN 100 PARTS:

Peroxide of iron, ...	84.22
Oxide of manganese, ...	0.41
Alumina, ...	0.65
Silica and insoluble matter, ...	6.43
Water, ...	8.25
	99.95

The proportion of metallic iron in this ore is 58.95 per cent.

IRON ORE from the Red Bank, three miles south-west of Rebecca Furnace, Morrison's Cove, Huntingdon county.

DESCRIPTION.

Texture, compact and close grained, somewhat jaspery; fracture slightly conchoidal; color bright reddish brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter, ...	32.1
Alumina, ...	a trace
Peroxide of iron, ...	57.2
Lime, ...	a trace
Water, ...	9.8
Loss, ...	0.9
	100.0

This specimen contains 40.04 per cent. metallic iron.

IRON ORE from Sarah Furnace Ore Bank, four miles south of M'Kee's Gap, Morrison's Cove, Bedford county.

DESCRIPTION.

Blackish brown; cellular; with concentric layers of denser crylstaline fibrous hematite.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	11.7
Alumina,	a trace.
Peroxide of iron,	76.5
Manganese,	a trace.
Water,	11.6
Loss,	0.2
	100.0

This specimen contains 53.55 per cent. metallic iron.

SECTION VI.

Analyses of Iron Ores of Formation III. (Slate.)

IRON ORE from the south side of Lowrey's Knob; Hanover Ore Bank, two and a-half miles north-east of Hanover Furnace, Bedford county.

DESCRIPTION.

Compact; brittle semi-crystalline; color, dark chocolate brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.80
Alumina,	3.20
Peroxide of iron,	80.20
Manganese,	a trace
Water,	12.90
Loss,	0.90
	100.00

This specimen contains 56.14 per cent. metallic iron.

IRON ORE from the Hanover Ore Bank.—Kind chiefly used at the Furnace.

DESCRIPTION.

Compact; fracture conchoidal; color dull brown; surface in patches, coated with a greenish black shining incrustation.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	11.5
Alumina,	2.0
Peroxide of iron,	73.6
Manganese,	a trace.
Water,	11.5
Lime,	a trace.
	98.6

This specimen contains 51.52 per cent. metallic iron.

IRON ORE from M'Naughton's, one and a-half miles west from Mercersburg, Franklin county.

DESCRIPTION.

A bog ore; dull brown, and cellular. It overlies the slate F. III.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	9.20
Alumina,	0.73
Peroxide of iron,	69.60
Water,	20.00
Loss,	0.47
	100.00

This specimen contains 48.72 per cent. metallic iron.

SECTION V.

Analyses of Iron Ores of Formation V.

IRON ORE from the Sandstone ridge, north-west side of Little Cove, four and a-half miles north of Warren Iron Works, Franklin county. (Specimen taken near the surface.)

DESCRIPTION.

Structure, slightly porous; laminated; fossiliferous; color, reddish brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.3
Alumina,	6.0
Peroxide of iron,	83.0
Manganese,	a trace
Lime,	0.5
Water,	5.1
Loss,	0.1
	100.00

This specimen contains 58.1 per cent. metallic iron.

Locality.—North-west side of Dickey's mountain, half a mile south of Lower Hanover Forge, Bedford county.

DESCRIPTION.

Structure, laminated; texture, earthy; color, dark chesnut brown, in some parts, almost black.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	39.3
Alumina,	a trace
Peroxide iron,	52.0
Manganese,	a trace
Water,	9.0
	100.3

This specimen contains 36.4 per cent. metallic iron.

IRON ORE from Matilda Furnace, two miles north-west of Newton Hamilton, Huntingdon county. (Upper division of the fossiliferous ore.)

DESCRIPTION.

Reddish brown, speckled with scales of grey micaceous oxide; cellular, from the removal of numerous minute fragments of fossils; breaks into rectangular pieces; streak red.

Specific gravity, 3.50

COMPOSITION IN 100 PARTS:

Peroxide of iron,	74,76
Alumina,	5.06
Lime,	1.35
Manganese,	a trace
Silica and insoluble matter,	13.04
Undetermined matter,	2.11
Water,	3.82
	100.14

This specimen contains 51.84 per cent metallic iron.

IRON ORE from Matilda Furnace.—(Lower division of the same bed.)

DESCRIPTION.

Brown, with a rectangular fracture; consists of coarse grains of siliceous sand, cemented by brown oxide of iron.

COMPOSITION IN 100 PARTS:

Peroxide of iron.	44.07
Manganese, ...	a trace
Alumina	1.39
Lime, ...	0.49
Silica and insoluble matter, ...	52.33
Water	2.62
	100.90

This specimen contains only 30.56 per cent. metallic iron. It is so highly siliceous as to make the smeltiug of it unprofitable.

IRON ORE used at Hopewell Furnace, from a vein on Dr. Andrew M'Dowell's land, found on the bank of Yellow creek, in Lick Hill, Woodcock Valley, Bedford county.

DESCRIPTION.

Structure, highly fossiliferous; particles of carbonate of lime disseminated through the mass; color, a pale red.

COMPOSITION IN 100 PARTS:

Peroxide of iron, ... } Carbonate of the protoxide, ... }	46.50
Alumina, ...	4.80
Carbonate of lime, ...	31.01
Silica and insoluble matter, ...	16.30
Water, ...	1 00
	99.61

From 39.60 per cent. of peroxide of iron obtained in the analysis, the amount of metallic iron in this specimen, is, by calculation, 27.72.

IRON ORE used at Hopewell Furnace, *softest kind*, obtained from upper vein two miles from the Furnace, Bedford county.

DESCRIPTION.

Texture, brittle and crumbly; disposed to break into irregular rhomboidal masses; color in mass, brown—of powder, rich purple brown; micaceous oxide sparsely disseminated throughout the mass; fossiliferous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	13.85
Alumina,	4.50
Peroxide of iron,	78.05
Sesquioxide of manganese,	0.68
Lime,	a trace
Water,	3.00
	100.28

This specimen contains 54.95 per cent. metallic iron.

IRON ORE used at Hopewell Furnace *compact kind*, obtained from upper vein, two miles from the Furnace.

DESCRIPTION.

Texture, compact; color of mass, reddish grey — of powder, light brown; structure, micaceous; fossiliferous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	8.8
Alumina,	1.0
Peroxide of iron,	55.2
Peroxide of manganese,	0.5
Lime,	17.6
Carbonic acid,	13.8
Water,	2.5
Loss,	0.6
	100.0

This specimen contains 38.64 per cent. metallic iron.

IRON ORE from the principal opening in the hill between Barre Forge and the Little Juniata, Huntingdon county—(lower portion of the vein.)

DESCRIPTION.

Structure, crystalline; distinctly fossiliferous; color, reddish grey calcareous.

COMPOSITION IN 100 PARTS:

Silica,	3.00
Alumina,	0.50
Peroxide of iron,	43.55
Proto-carbonate of iron,	3.56
Sesquioxide of manganese,	0.50
Carbonate of lime,	46 76
Water,	1.50
	99.37

This specimen contains 32.2 per cent. metallic iron.

IRON ORE from near Little Juniata, at Barre Forge, North-East of the Forge—(average specimen of the vein.)

DESCRIPTION.

Compact; breaks into rectangular plates; color, reddish grey; micaceous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	7.50
Alumina,	1.40
Protoxide of iron,	57.00
Peroxide of manganese,	0.60
Lime,	18.00
Carbonic acid,	14.10
Water,	2.00
	100.60

This specimen contains 39.9 per cent. metallic iron.

SECTION VI.

Analyses of Iron Ores of Formation VI.

IRON ORE from Allegheny Furnace Ore Bank, six miles from Tuckahoe, Huntingdon county. This ore comes from near the contact of F. VI. and F. VII.

DESCRIPTION.

Amorphus; compact; brittle; fracture earthy; color, dark bluish brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	6.0
Alumina,	a trace
Peroxide of iron,	82.2
Peroxide of manganese,	8.0
Water,	4.0
	100.2

This specimen contains 57.54 per cent. metallic iron.

IRON ORE from Allegheny Furnace, six miles from Tuckahoe, Huntingdon county.

DESCRIPTION.

Pipe ore; the stems or pipes large; portions of the surface irridescent.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	86.91
Alumina,	0.22
Silica and insoluble matter,	1.93
Water,	10.44
	99.50

This specimen contains 60.26 per cent. metallic iron.

IRON ORE from one mile South-West of Bell's Furnace, Tuckahoe, Huntingdon county. This ore seems to be derived from F. VII.

DESCRIPTION.

Color, a dark chocolate brown; lustre somewhat resinous. This variety is said to make a brittle iron.

COMPOSITION IN 100 PARTS.

Peroxide of iron,	73.28
Oxide of Manganese,	a trace
Alumina,	5.52
Silica and insoluble matter,	12.88
Water,	9.38
	101.06

This specimen contains 50.81 per cent. metallic iron.

Section VII.

Analyses of Iron Ores from Formation VIII.

Iron Ore from the Synclinal Axis, Nevey's Bank, one and a half miles South-east of Newton Hamilton, Lewistown Valley, Huntingdon county. This ore occurs near the contact of Fs. VII. and VIII.

DESCRIPTION.

Structure imperfectly laminated; somewhat cellular; color, dull mottled brown; highly silicious.

Composition in 100 parts:

Silica and insoluble matter,	20.5
Alumina,	4.6
Peroxide of iron,	65.4
Manganese,	a trace
Water,	9.0
Loss,	0.5
	100.0

This specimen contains 45.78 per cent. metallic iron.

Iron Ore from the Synclinal Axis, half a mile West of Brookland Furnace, (Walter's Bank,) Lewistown Valley, Mifflin county. Occurs near the contact of Fs. VII. and VIII.

DESCRIPTION.

Structure, hematitic; color, rich chocolate brown; surface velvet like, and occasionally brilliantly irridescent.

Composition in 100 parts:

Silica and insoluble matter,	18.80
Alumina,	5.80
Peroxide of iron,	66.00
Water,	9.00
Manganese,	a trace
	99.60

This specimen contains 46.2 per cent. metallic iron.

IRON ORE from Warren Ore Bank, North-West side of Synclinal Axis of Little Cove, and a half a mile North-West of the Iron Work, Franklin county.

DESCRIPTION.

Structure, hollow or shell-like; color, dark brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	18.8
Alumina,	a trace
Peroxide of iron,	67.6
Manganese,	a trace
Water,	12.7
Loss,	0.9
	100.0

This specimen contains 47.32 per cent. metallic iron.

IRON ORE from Brown's Furnace, Little Cove, Franklin county.

DESCRIPTION.

Compact; nodular; color, bluish grey. Occurs as a regular stratum in the lower beds of F. VIII. in various places.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	17.00
Alumina,	1.50
Protoxide of iron,	50.00
Carbonic acid,	30.55
Water,	1.00
	100.05

This specimen contains 38.8 per cent metallic iron. This valuable ore has never been worked, though it is obviously rich enough and sufficiently pure. The quantity of it in many of the synclinal basins of F. VIII., where it often forms a regular seam, is inexhaustible.

Section VIII.

Analysis of Iron Ores from Formations IX.

Iron Ore from Larry's Creek, Lycoming county, (near the contact of F. VIII. and F. IX.

DESCRIPTION.

Purplish brown; streak red; structure stratified or laminated; consists of flattish granules; fossiliferous; somewhat sandy.

Composition in 100 parts:

Silica and insoluble matter,	32.30
Alumina,	3.09
Peroxide of iron,	61.20
Carbonate of lime,	1.30
Water,	2.20
	100.00

This specimen contains 42.84 per cent. metallic iron. It does not manifest, by analysis, the faintest trace of manganese.

Iron Ore from the north-west side of Big Scrub Bridge, and two and a half miles south-west of the turnpike. Occurs near the contact of F. IX. F. X.

DESCRIPTION.

Compact, fibrous, hematitic; color, dark mahogany brown.

Composition in 100 parts:

Silica and insoluble matter,	2.85
Alumina,	a trace
Peroxide of iron,	84.54
Water,	12.00
	99.39

This specimen contains 59.17 per cent. metallic iron.

Section IX.

Analysis of Iron Ores from formation XI.

Iron Ore from Hopewell Furnace, from old bank, on north side of the river. The best kind used from this opening, occurs near the contact of F. X. and F. XI.

DESCRIPTION.

Nodular, geodiferous; surface coated with a pinkish deposite—interiorly by a velvet like oxide.

Composition in 100 parts:

Silica and insoluble matter,	32.1
Alumina,	2.5
Peroxide of iron,	60.0
Lime,	0.4
Manganese,	a trace
Water,	4.5
Loss,	0.4
	100.0

This specimen contains 42.0 per cent. metallic iron.

Iron Ore from a vein in a tunnel in Terrace mountain, Hopewell Furnace. Occurs near the contact of F. X. and F. XI.

DESCRIPTION.

Massive, compact; fracture, coincidal; lustre, dull; color, chocolate brown.

Composition in 100 parts:

Silica and insoluble matter,	2.30
Alumina,	a trace.
Manganese,	a trace
Peroxide of iron,	84.00
Water,	13.50
Loss,	0.20
	100.00

This specimen contains 58.8 per cent. metallic iron.

IRON ORE from Ralston, Lycoming county, (upper part of the bed.)

DESCRIPTION.

Spathose; texture, somewhat laminated; siliceous; color, ash grey.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	28.80
Alumina,	1.00
Protoxide of iron,	41.22
Lime,	0.50
Carbonic acid,	24.00
Water,	4.28
Loss,	0.5
	100.00

This specimen contains 32.06 per cent. metallic iron.

IRON ORE from the upper part of a bed in West Hill, Johnson's creek Blossburg.

DESCRIPTION.

Spathose; texture somewhat laminated; color, light grey, with faint pink hue; highly siliceous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	66.80
Alumina,	0.50
Protoxide of iron,	18.54
Carbonic acid,	11.30
Manganese,	a trace.
Water,	2.56
Loss,	0.30
	100.00

This specimen contains only 14.42 per cent. metallic iron.

IRON ORE from the bed at Astonville, Frozen run, Lycoming county.

DESCRIPTION.

Light grey, mottled; consists of minutely chrystaline carbonate of iron; of a pinkish yellow color, sometimes velvet like,

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	28.7
Alumina,	0.8
Protoxide of iron,	42.2
Carbonate of lime,	0.6
Carbonic acid	25.8
Water,	1.5
	99 6

This specimen contains 32.8 per cent. metallic iron.

IRON ORE from the lower band of Red Shale, F. XI., Farrandsville, Lycoming county.

DESCRIPTION.

Color, purplish red; compact dense, nodular, and very slightly crystalline.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	25.6
Alumina,	3·6
Peroxide of iron,	68.4
Carbonic acid and water,	2.0
Lime,	a trace
	99.6

This specimen contains 47.88 per cent. metallic iron.

SECTION X.

Analyses of Iron Ores from the Coal Measures of F. XIII., (Anthracite Coal Region.)

IRON ORE from Pottsville, from a bed of huge balls, in a tunnel running north from the Gate vein.

DESCRIPTION.

Texture compact, and close grained; fracture, slightly conchoidal; color, slate blue; feel, slightly unctuous; breaks into irregular shaped masses, which are covered at the surface, of a contact with thin plates of white silicious matter.

COMPOSITION IN 100 PARTS:

Carbonate of iron,	80.85
Carbonate of lime,	1.00
Carbonate of Magnesia	3.86
Alumina,	2.06
Silica and insoluble matter,	9.08
Carbonaceous matter,	1.02
Water,	2.00
	99.87

This specimen contains 39.09 per cent. metallic iron.

IRON ORE from the tunnel of the North American Works, Pottsville.

DESCRIPTION.

Compact; texture, rather coarse grained; feel, unctious; interspersed with irredescent spots of iron Pyrites.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	50.80
Alumina,	2.80
Carbonate of iron,	39.82
Carbonate of lime,	1.00
Carbonate of Magnesia,	2.35
Manganese,	a trace
Sulphur,	a trace
Water,	2.00
Carbonaceous matter,	1.20
	99.97

This specimen contains 19.21 per cent. metallic iron.

IRON ORE from the outcrop of a bed next below the rabbit hole vein, Eyre tract, Pottsville.

DESCRIPTION.

Occurs in oval lenticular shaped masses; external structure, concentric; color, dull brown; internally, slate blue.

COMPOSITION IN 100 PARTS:

Carbonate of iron,	65.30
Oxide of manganese,	a trace
Alumina,	3.20
Carbonate of lime,	1.50
Carbonate of Magnesia,	1.60
Silica and insoluble matter,	25.00
Organic matter,	1.22
Water,	1.50
	99.32

This specimen contains 32.6 per cent. metallic iron.

IRON ORE from the outcrop of a bed found ten feet below a seam of coal, opened by B. Patterson, Pottsville.

DESCRIPTION.

Irregularly rounded mass, very hard; color, light slate blue; highly siliceous.

COMPOSITION IN 100 PARTS:

Carbonate of iron,	67.80
Carbonate of manganese,	1.00
Carbonate of lime,	0.39
Carbonate of magnesia,	a trace.
Alumina,	1.30
Silica and insoluble matter,	29.00
Water,	0.50
	99.99

This specimen contains 33.9 per cent. metallic iron.

IRON ORE from M'Carty's Tunnel, Pottsville.

DESCRIPTION.

Iregular rounded mass, somewhat micaceous; feel, slightly unctuous; colr slate blue, and in the centre a little irridescent.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	19.36
Carbonate of iron	26.02
Mangancse,	a trace
Alumina,	2.08
Carbonate of lime,	0.07
Carbonate of Magnesia	4.04
Silica and insoluble matter,	46.40
Water,	1.00
	98.97

This specimen contains 26.39 per cent. metallic iron.

IRON ORE from one of several bands near the end of Mann and Williams' Tunnel, Pottsville.

DESCRIPTION.

Texture, compact and close grained; aspect, earthy; fracture, slaty; surface, smooth; feel, unctuous; color, slate blue.

COMPOSITION IN 100 PARTS:

Carbonate of iron,	72.00
Manganese,	a trace
Carbonate of lime,	2.08
Carbonate of magnesia,	1.52
Alumina,	1.60
Silica and insoluble matter,	21.50
Carbonaceous matter,	1.00
Sulphur,	a trace
Water,	3,0
	100.00

This specimen contains 36 per cent. metallic iron.

IRON ORE from a bed south of the false Salem vein, Guinea Hill, on Market street, Pottsville.

DESCRIPTION.

Irregular nodular mass, compact interiorly; on surface, brittle and somewhat laminated; color interior, slate blue; surface, ocherous brown; aspect, earthy and micaceous.

COMPOSITION IN 100 PARTS:

Peroxide and carbonate of iron,	56.20
Alumina,	2.80
Manganese,	a trace
Carbonate of lime,	a trace
Carbonate of magnesia,	0.8
Silica and insoluble matter,	39.30
Carbonaceous matter,	0.50
Water,	0.20
	99.80

The proportion of metallic iron in this specimen is 32.48 per cent.

IRON ORE from a bed behind a barn on Guinea Hill, Pottsville.

DESCRIPTION.

Similar to the above, except that the external portion is more distinctly laminated.

COMPOSITION IN 100 PARTS:

Peroxide and carbanate of iron,	63.3
Alumina,	2.8
Lime,	a trace
Carbonate of magnesia,	1.4
Silica and insoluble matter,	32.0
Water,	0.4
	99.9

This specimen contains 30.66 per cent. metallic iron.

IRON ORE from Pottsville, from a collection of veins near the north end of Mann and Williams' tunnel.

DESCRIPTION.

Texture, compact and close grained; aspect, earthy; fracture, slightly conchoidal; feel, little unctuous; color, slate blue.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	15.00
Alumina,	2.60
Peroxide and carbonate of iron,	79.20
Lime,	a trace.
Magnesia,	a trace.
Manganese,	a trace.
Water,	1.60
Carbonaceous matter,	1.30
	99.70

This specimen contains 2.84 per cent. metallic iron.

IRON ORE from a bed behind a barn on Guinea hill, north of the false Salem; vein, fourteen inches thick.—Pottsville.

DESCRIPTION.

Texture, compact; close grained; fracture, slightly conchoidal; aspect, earthy; color, slate blue; feel, smooth and unctuous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	21.00
Alumina,	1.60
Peroxide of iron,	44.64
Insoluble carbonaceous matter,	1.00
Lime,	0.70
Magnesia,	0.70
Carbonic acid,	27.05
Water,	1.40
	99.54

This specimen contains 34.72 per cent. metallic iron.

Iron Ores of the Bituminous Coal Measures.

IRON ORE from the "Deal Bank," one mile south of Shippenville, Clarion county. (Buhr-stone ore.)

DESCRIPTION.

Hematitic; cellular; interior cells coated with small crystalline oxide; color, purple brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.81
Alumina,	a trace.
Peroxide of iron,	83.00
Sesquioxide of manganese,	2 00
Water,	12.50
	100 31

The proportion of metallic iron in this specimen, is 58.1 per cent.

IRON ORE from the land of Mr. M'Ginnis, used at Porterfield's Furnace, Clarion county. (Buhr-stone ore.)

DESCRIPTION.

Hematic, slightly cellular; color, purplish brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.30
Alumina,	a trace.
Peroxide of iron,	79.20
Sesquioxide of manganese,	1.00
Water,	14.00
	99.50

This specimen contains 55.44 per cent. metallic iron.

IRON ORE from the land of Mr. M'Ginnis, used at Porterfield's Furnace, Clarion county. (Buhr-stone ore.)

DESCRIPTION.

Irregular shaped: nodular, with a dense nucleus enveloped by a laminated and concentrive crust; color, reddish brown; structure, somewhat oolitic.

COMPOSITION IN 100 PARTS:

Silica,	21.50
Alumina,	0.70
Peroxide of iron,	45.04
Carbonic acid,	25.30
Carbonate of lime,	1.78
Carbonate of manganese,	1.00
Water,	4.00
	99.68

This specimen contains 35.03 per cent. metallic iron.

IRON ORE from Rockland Furnace, Venango county, (Nodular, or Ball ore.)

DESCRIPTION.

Texture, hard and compact; nodular; fracture, somewhat conchoidal; color, dark slate blue—externally brown.

COMPOSITION IN 100 PARTS:

Carbonate of iron,	79.90
Carbonate of lime,	2.60
Oxide manganese,	.05
Alumina,	.50
Silica and insoluble matter,	14.80
Organic matter,	a trace
Water,	2.00
	99.85

This specimen countains 38.05 per cent. metallic iron.

IRON ORE from the land of Joseph Kutcher, Clarion county, (Buhrstone ore.)

DESCRIPTION.

Spathose; texture, compact; fracture, conchoidal; color, bluish grey.

COMPOSITION IN 190 PARTS:

Carbonate of iron,	76.30
Alumina,	1.00
Carbonate of lime,	6.00
Silica and insolubie matter,	13.30
Oxide of manganese,	.50
Water,	2.00
	99.10

The proportion of metallic iron in this specimen, is 59.03 per cent.

Iron Ore from the land of Jos. Kucher, Clarion co. (Buhr stone ore.)

DESCRIPTION.

Texture, soft and porous; fracture, irregular; aspect, earthy; color, dull red, speckled with white spots.

COMPOSITION IN 100 PARTS:

Peroxide of iron, and Carbonate of iron,	87.04
Alumina,	.05
Carbonate of lime,	4.06
Silica and insoluble matter,	5.08
Water,	1.05
	99.08

This specimen contains 54.14 per cent metallic iron.

IRON ORE from Lucinda Furnace, (Huges's) Clarion county, (Buhr-stone ore.)

DESCRIPTION.

Structure, geodiferous, cellular; walls composed of imperfectly crystallized hæmatite; interior of cells coated with a firm ocherous deposite; color, chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.80
Alumina,	0.54
Peroxide of iron,	78.22
Sesquioxide of manganese,	1.50
Water,	14.20
	99.29

This specimen contains 54.75 per cent. of metallic iron.

IRON ORE from Phipp's furnace, Scrub Grass township, Venango co. (ball ore.)

DESCRIPTION.

Texture, hard, compact; fracture conchoidal; somewhat nodular: interior, slate blue—outside brown.

COMPOSITION IN 100 PARTS:

Peroxide of iron and carbonate of iron,	96.00
Manganese,	a trace.
Alumina,	0.50
Lime,	a trace.
Silica and insoluble matter,	2.10
Organic matter,	a trace.
Water,	1.00
	99.60

This speimen contains 41.3 per cent. metallic iron.

IRON ORE from Hickory Furnace, Butler county, (Buhr-stone ore.)

DESCRIPTION.

Nodular, cellular; walls of cells composed of chrystalized hematite and lined with a rich velvet like oxide; color, bright chesnut brown; surface coated with a thin argillaceous crust.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	20.0
Alumina,	1.8
Peroxide of iron,	65.2
Peroxide of manganese,	1.5
Water,	11.0
	99.5

The amount of metallic iron in this specimen, is 45.64 per cent.

IRON ORE from Madison Furnace, Clarion county, (Buhr-stone ore.)

DESCRIPTION.

Externally cellular; interior compact: color, mass dull brown—of surface, ocherous; aspect siliceous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	7.7
Alumina,	3.6
Peroxide of iron,	76.1
Lime and magnesia,	traces.
Water,	12.5
	99.9

This specimen contains 53.27 per cent. metallic iron.

BOG IRON ORE from Smullen's Furnace, Venango county.

DESCRIPTION.

Soft, earthy, pulverulent; color, rich brown yellow; finely powdered, color more brilliant—Bog ore.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	3.8
Alumina,	a trace.
Peroxide of iron	80.12
Oxide of manganese,	0.50
Water,	13.00
Organic matter,	2.00
	99.42

This specimen contains 56.07 per cent. metallic iron.

Bog Iron Ore from Hickory Furnace, from M'Cullum's bank, Butler County.

DESCRIPTION.

Brittle, earthy mass; containing thin plates of imperfectly crystallized hæmatite; color, bright cinnamon brown—Bog ore.

Composition in 100 parts:

Silica and insoluble matter,	4.8
Alumina,	a trace.
Peroxide of iron,	78.6
Oxide of manganese,	0.4
Organic matter	2.0
Water,	14.0
	99.8

This specimen contains 55.02 per cent. metallic iron.

Iron Ore from Bear Creek Hill, Blossburg, Tioga county.

DESCRIPTION.

Color, mottled, reddish and grey; structure, compact, granular, oolitic; in some parts crystalline.

Composition in 100 parts:

Carbonate of iron,	44.79
Peroxide of iron,	8.41
Carbonate of manganese,	0.88
Carbonate of magnesia and a little manganese	1.99
Alumina,	0.34
Silica and insoluble matter,	37.28
Water,	6.23
	99.92

The proportion of metallic iron in this specimen is 27.05 per cent.

Iron Ore from a part of the same bed with the above—Blossburg.

DESCRIPTION.

Occurs in elongated nodules; color, dingy brown externally—ochrey within; breaks by concentrive layers; soft and somewhat earthy; speckled; showing a tendency to an oolitic structure.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	26.69
Oxide of manganese,	0.32
Magnesia with a minute trace of manganese,	0.44
Alumina,	1.88
Silica and insoluble matter,	59.36
Water,	10.52
	99.21

The proportion of metallic iron in this specimen, which is a fair average of the class of ores to which it belongs, is only 18.51 per cent.

SECTION XI.

Analyses of Iron Ores from the Middle Secondary Red Sandstone Formation.

MAGNETIC IRON ORE from Daniel Feglie's mine, Boyerstown, Colebrookdale township, Berks county.

DESCRIPTION.

Color, dark dull grey, approaching black, with glimmering crystalline points; powder, black; shows a very slight effervescence by an acid; contains some green chloritic clay; acts on the magnetic needle; occurs in a vein in the red shale, near its contact with the primary rocks of the South Mountains.

COMPOSITION IN 100 PARTS:

Magnetic oxide of iron,	86.67
Alumina,	1.36
Carbonate of lime,	0.80
Magnesia,	2.60
Silica and insoluble matter,	7.72
Water,	0.80
	99.95

The proportion of metallic iron in this ore is 62.22 per cent

MAGNETIC IRON ORE from the Warwick mine, near Morgantown, Berks county.

DESCRIPTION.

Color, black; lustre, metallic, but rather dull; contains numerous cavities, the walls of which are coated with ferruginous and talcose matter, and with perfect crystals of oxydulated iron, in rhombic dodecahedron's the ore possesses magnetic polarity.

COMPOSITION IN 100 PARTS:

Magnetic oxide of iron, ...	97.61
Alumina, ...	a trace.
Silica and insoluble matter	1.69
	99.30

The proportion of metallic iron in this specimen, is 70.19 per cent. No titanic acid could be detected in it.

MAGNETIC IRON ORE from Cornwall mine, Lebanon county.

DESCRIPTION.

Nearly black; aspect dull, with brilliant points; somewhat cellular; the little cavities containing small oxtohedral crystals of the magnetic oxide. They contain also a whitish asbestiform mineral. The ore possesses magnetic polarity. The water which it shows by analysis, is probably, only hygrometric.

COMPOSITION IN 100 PARTS:

Magnetic oxide of iron, ...	97.99
Alumina, ...	0.84
Silica and insoluble matter, ...	0.24
Water, ...	0.12
	99.19

This specimen contains 70.34 per cent. metallic iron.

SECTION XII.

Analyses of Cast Irons.

CAST IRON, manufactured from the fossiliferous ore of Montours Ridge, near Bloomsburg, Columbia county, at Esther Furnace.

DESCRIPTION.

A dull grey soft iron, uniformly and rather coarsely crystaline.

COMPOSITION IN 100 PARTS:

Pure iron,	96.100
Silicium,	0.100
Aluminium,	a mere trace.
Manganese,	0.224
Corbon,	3.500
	99.924

CAST IRON manufactured at M'Nichols Furnace, near Kittaning, from the Buhr-stone ore of Armstrong county.

DESCRIPTION

A soft grey metal, of an uniform, well developed crystaline grain.

COMPOSITION IN 100 PARTS:

Pure iron,	89.63
Silicium,	5.44
Aluminium,	0.65
Manganese,	0.12
Carbon,	3.90
Phos. and sulphur,	traces.
	99.74

MISCELLANEOUS SUBSTANCES.

Analysis of a *Cadmia*, or incrustation on the in-walls of Mary Ann Furnace, belonging to Whitehill and Ellis, Cumberland county.

COMPOSITION IN 100 PARTS:

Oxide of zinc,	92.48
Oxide of lead,	6.48
Peroxide of iron,	1.00
Carbonaceous matter,	a trace
	99.96

It manifested scarcely a trace of either sulphur or manganese, nor could oxide of cadmium or any other metallic matter, except those shown above, be detected. Incrustations of this nature are not unfrequent in furnaces, and when originally noticed, received the name of cadmia.

CONCLUSION.

Besides the extensive suite of iron ores here presented, we have analysed an equally numerous series of Coals and Limestones. The relation which these several substances mutually possess, as the three great essentials in the manufacture of iron, renders the precise determination of their chemical nature in each instance, a point of high practical importance to a leading branch of our domestic industry. I am, therefore, conducting a systematic chemical investigation, into the properties of all our ores, fuels and varieties of flux employed, intending to extend the inquiry to the several kinds of cast and maleable iron which our State produces. As much preliminary labor is to be encountered before this portion of our researches will be in a condition for publication, I shall postpone all general conclusions connected with the several circumstances affecting the quality and quantity of iron afforded by different ores, until the opportunity is furnished me for discussing this subject at large, in the pages of my final report. Let me, in the mean while, however, allude to one obvious and important fact, the discrepency in the amount of iron here shown to exist in our ores, compared with that which they produce when smelted by the methods in common use. With a few exceptions, the charcoal furnaces of this State do not get from the ore more than about 40 per cent. metallic iron, and many, not more than 33 per cent.—whereas, it appears from the foregoing analyses, that a large class of the ores employed, contain more than 50 per cent. of metal. This serious waste is mainly attributable, I conceive, to the use of furnaces of too small a size, to too weak a species of fuel, but especially, to too feeble a blast: circumstances all tending to cause a heat insufficient for the thorough reduction of the ore.

Respectfully submitted,

HENRY D. ROGERS.

PHILADELPHIA, *February*, 1 1840.

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